E.O. Lawrence Berkeley National Laboratory
University of California

United States Department of Energy

QUALITY ASSURANCE PROJECT PLAN

FOR TRITIUM SAMPLING

for the

Lawrence Berkeley National Laboratory

April 2001

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LIST OF ABBREVIATIONS

AASP	Ambient Air Sampling Program
ANSI	America National Standards Institute
Berkeley Lab	Lawrence Berkeley National Laboratory
Bq	Becquerels
Bq/g	Becquerels per gram
Bq/L	Becquerels per liter
Bq/m^3	Becquerels per cubic meter
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci	Curie
COC	chain-of-custody
DHS	California Department of Health Services
DOE	U.S. Department of Energy
DQOs	Data Quality Objectives
DTSC	Cal-EPA Department of Toxic Substances Control
EH&S	Environment, Health and Safety Division
EPA	U. S. Environmental Protection Agency
ERG	Environmental and Radiation Protection group
ERP	Environmental Restoration Program
ESG	Environmental Services Group
ESPTF	Environmental Sampling Project Task Force
FY	Fiscal year (October 1 through September 30)
HRS	Hazard ranking System
HT	Gaseous tritium
HTO	Tritiated water
LCS	Laboratory Control Standard
MDA	Minimum Detectable Activity
mL	Milliliters
MS/MSD	Matrix spike and matrix spike duplicate
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
NIH	National Institute of Health
NIST	National Institute of Standards and Technology
NPL	National Priorities List
NTLF	National Tritium Labeling Facility
OBT	Organically Bound Tritium
%R	Percent recovery
pCi	Picocuries
pCi/L	Picocuries per liter
pCi/m^3	Picocuries per cubic meter
pCi/g	picocuries per gram (10^{-12} Curies per gram)

PE	Performance Evaluation
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAML	Radiation and Analytical Measurements Laboratory
RCRA	resource Conservation and recovery Act
RL	Reporting Limit
RPD	Relative percent difference
RWQCB	Regional water Quality Control Board
SOP	Standard Operating Procedure
TFWT	Tissue free-water tritium
TSA	Technical Systems Audit
UC	University of California
VSP	Vegetation Sampling Program

SECTION 1

INTRODUCTION

1.1 BACKGROUND

The E.O. Lawrence Berkeley National Laboratory (Berkeley Lab) is a multipurpose research facility operated by the University of California (UC) as part of the U.S. Department of Energy's (DOE) national laboratory system. The location of Berkeley Lab is shown on Figure 1.1. It encompasses approximately 80 hectares (200 acres) of land on the northeast side of the UC Berkeley (UCB) campus in the Berkeley/Oakland hills in Alameda County, California. The regional setting of Berkeley Lab is shown on Figure 1.2. The western two-thirds of the site are in the City of Berkeley and the eastern third is in the City of Oakland. Figure 1.3 is a detailed map of the site showing the locations of buildings and site topography.

Berkeley Lab activities are conducted in compliance with the environmental requirements of applicable regulatory agencies and DOE orders. Berkeley Lab operates in an environmentally responsible manner, and is responsive to the concerns of the community in which it operates. Berkeley Lab's Environmental and Radiation Protection Group (ERG) is responsible for administering environmental protection and compliance programs at Berkeley Lab. ERG's Environmental Services Group (ESG) oversees the site-wide environmental compliance efforts, including Berkeley Lab's environmental monitoring and surveillance programs and is responsible for implementing this Quality Assurance Project Plan (QAPP).

Additionally, Berkeley Lab operates under a Resource Conservation and Recovery Act (RCRA) Part B Permit for its Hazardous Waste Handling Facility. The Permit requires that Berkeley Lab investigate and address all releases of hazardous waste or hazardous constituents that may have occurred at its facility. Investigations of areas of potential environmental contamination, including soil, surface water, sediment, and groundwater, are conducted at Berkeley Lab under the Environmental Restoration Program (ERP) of the ESG.

Figure 1.1. Location of the Lawrence Berkeley National Laboratory

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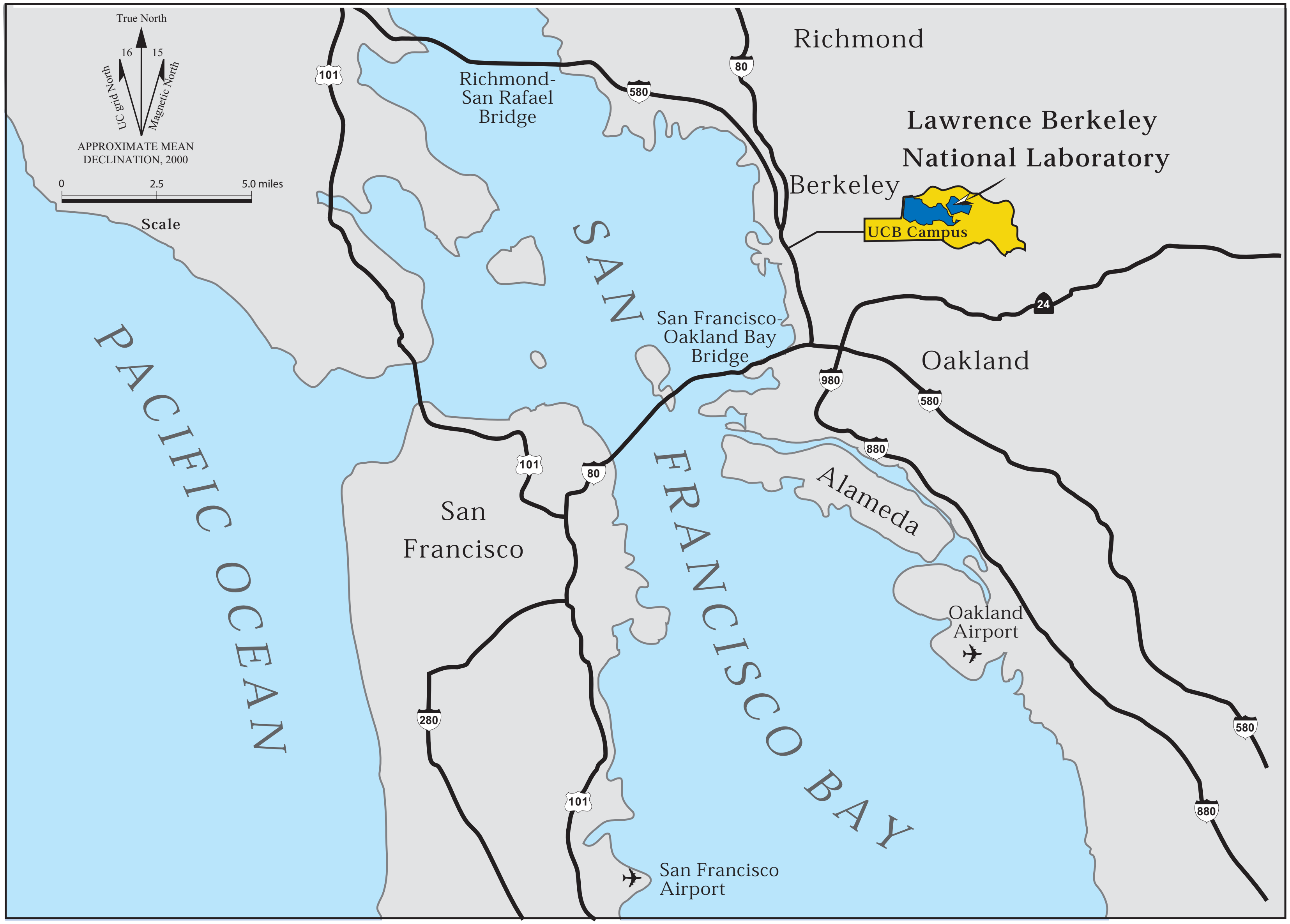

Figure 1.2. Regional Setting of the Lawrence Berkeley National Laboratory (Berkeley Lab)

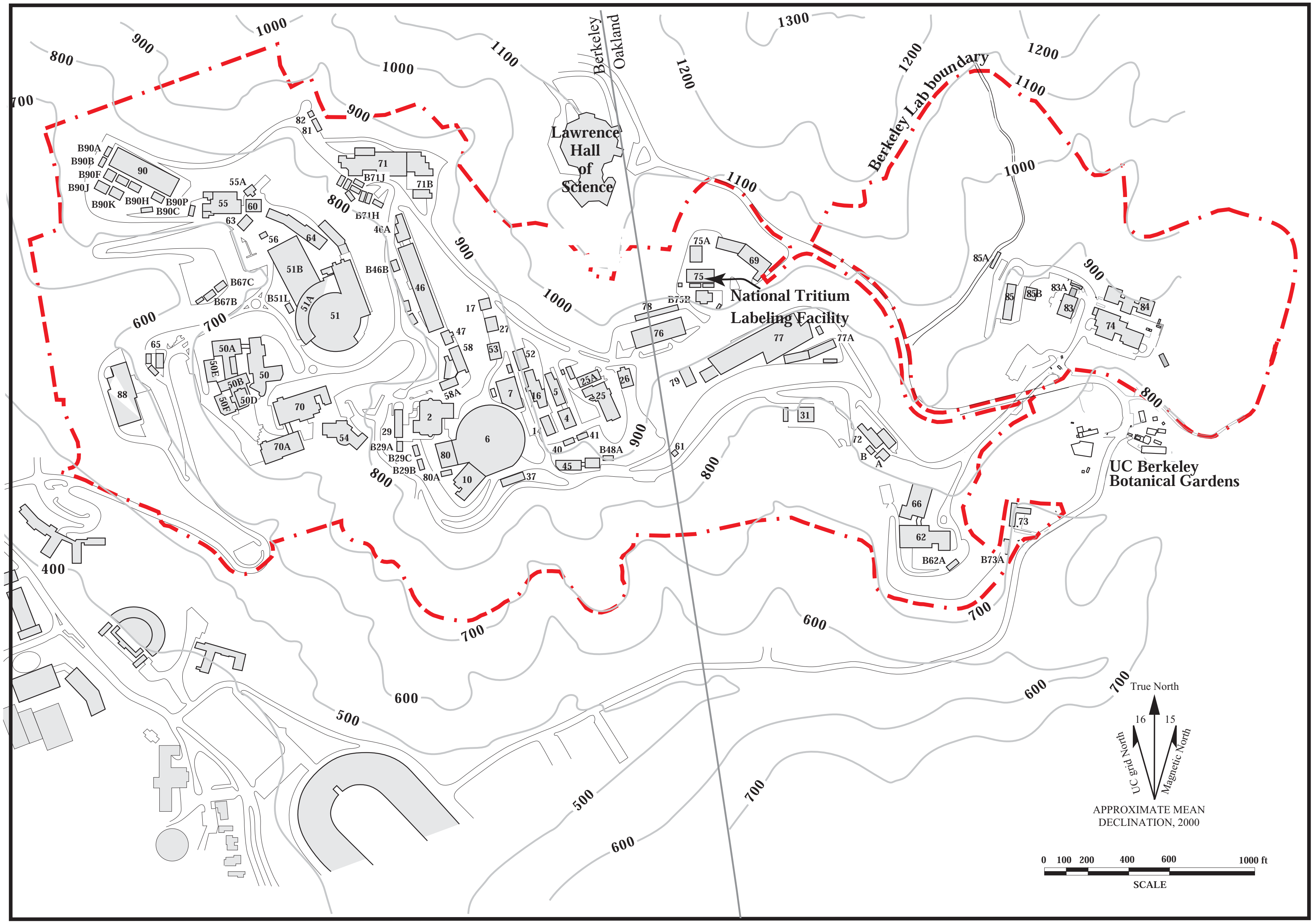

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Figure 1.3. Site Map and Topography, Lawrence Berkeley National Laboratory (Berkeley Lab).

The ERP represents Berkeley Lab's participation in DOE's nationwide effort to identify and clean up contaminated areas at its facilities.

In 1991, the United States Environmental Protection Agency (EPA) initially evaluated Berkeley Lab under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for possible inclusion on the National Priorities List (NPL) (federal Superfund list). At that time, the EPA determined that Berkeley Lab did not qualify for the list (EPA 1991).

In 1997, the Committee to Minimize Toxic Waste (a local community group) petitioned the EPA to re-evaluate Berkeley Lab for possible inclusion on the Superfund list, based on results of tritium sampling conducted since the 1991 evaluation. EPA released its Superfund Evaluation Report in August 1998, with a preliminary finding that Berkeley Lab was potentially eligible for the Superfund list because ambient tritium levels in air sometimes exceeded the screening criteria used in Superfund Hazard Ranking System (HRS) scoring. EPA uses the HRS to evaluate the potential risks to human health or the environment posed by different sites. However, the EPA had no immediate plans to add Berkeley Lab to the list because it recognized that tritium emissions at the National Tritium Labeling Facility (NTLF) are well below national public health standards set under EPA's National Emission Standards for Hazardous Air Pollutants (NESHAPs) regulations under 40 Code of Federal Regulations (CFR) Part 61. EPA reported that while the NTLF operations have resulted in small tritium levels in nearby groundwater, surface water, soil, and tree leaves, the data did not show significant tritium concentrations to require cleanup.

In a letter dated September 3, 1998, however, the EPA requested that DOE collect additional ambient air, soil, surface water, and sediment samples in accordance with Superfund HRS requirements before it could complete its Superfund evaluation of the Berkeley Lab site. A copy of the letter is included in Attachment 2. This QAPP establishes the Quality Assurance/Quality Control (QA/QC) requirements for collecting the supplemental information requested by EPA. In addition, because of community concerns (City of Berkeley 1996), Berkeley Lab will also collect supplemental samples of vegetation and plant-transpired water, in accordance with requirements established in this QAPP. The sampling requirements are specified in the three field sampling plans (soil, sediment, and surface water; ambient air; and vegetation) included in Attachment 1 of this QAPP.

The format and elements of this QAPP are in accordance with EPA guidance documents including *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations EPA QA/R5 October 1997* and *EPA Guidance for Quality Assurance Project Plans EPA QA/G-5 February 1998*. This QAPP is in effect only while Berkeley Lab collects the supplemental samples for tritium analysis as requested by EPA, and any associated samples.

1.2 OBJECTIVES

The primary objective of the environmental investigations described in the Field Sampling Plans (Attachment 1) is to collect data of the appropriate type and quality for EPA to decide whether to place Berkeley Lab on the NPL. In addition the data will be used to evaluate the tritium fate and transport model used in the Environmental Health Risk Assessment for Tritium Releases at the National Tritium Labeling Facility at Berkeley Lab (McKone, *et al.* 1997).

The purpose of this QAPP is to provide project-specific guidance on how QA and QC procedures will be applied in order to meet these objectives. Specific elements required in a QAPP include project management, data acquisition, assessment and oversight, and data validation and usability. These elements are discussed in the following four sections.

SECTION 2

PROJECT MANAGEMENT

This section describes the organization of the project, problem definition, project tasks, project schedule, project quality objectives, criteria for measurement data, special training requirements, and documentation and records requirements.

2.1 PROJECT ORGANIZATION

A chart depicting the organization of the data generators and their relationship to the primary data users is shown on Figure 2.1. The data generators include Berkeley Lab and the laboratories that will analyze the samples collected under this QAPP. The principal users of the data will be the regulatory agencies. The roles of both the data generators and data users are described below.

2.1.1 Data Generators

This section describes the roles of staff responsible for data collection, data management, and QA issues.

Environmental Services Group (ESG) Leader

The ESG Leader is Mr. Ron Pauer. Mr. Pauer has overall responsibility for ensuring that appropriate QA measures are implemented for site surveillance and monitoring activities, site characterization, and corrective actions associated with federal, state and local environmental regulations pertinent to Berkeley Lab. He is also responsible for maintaining the QAPP.

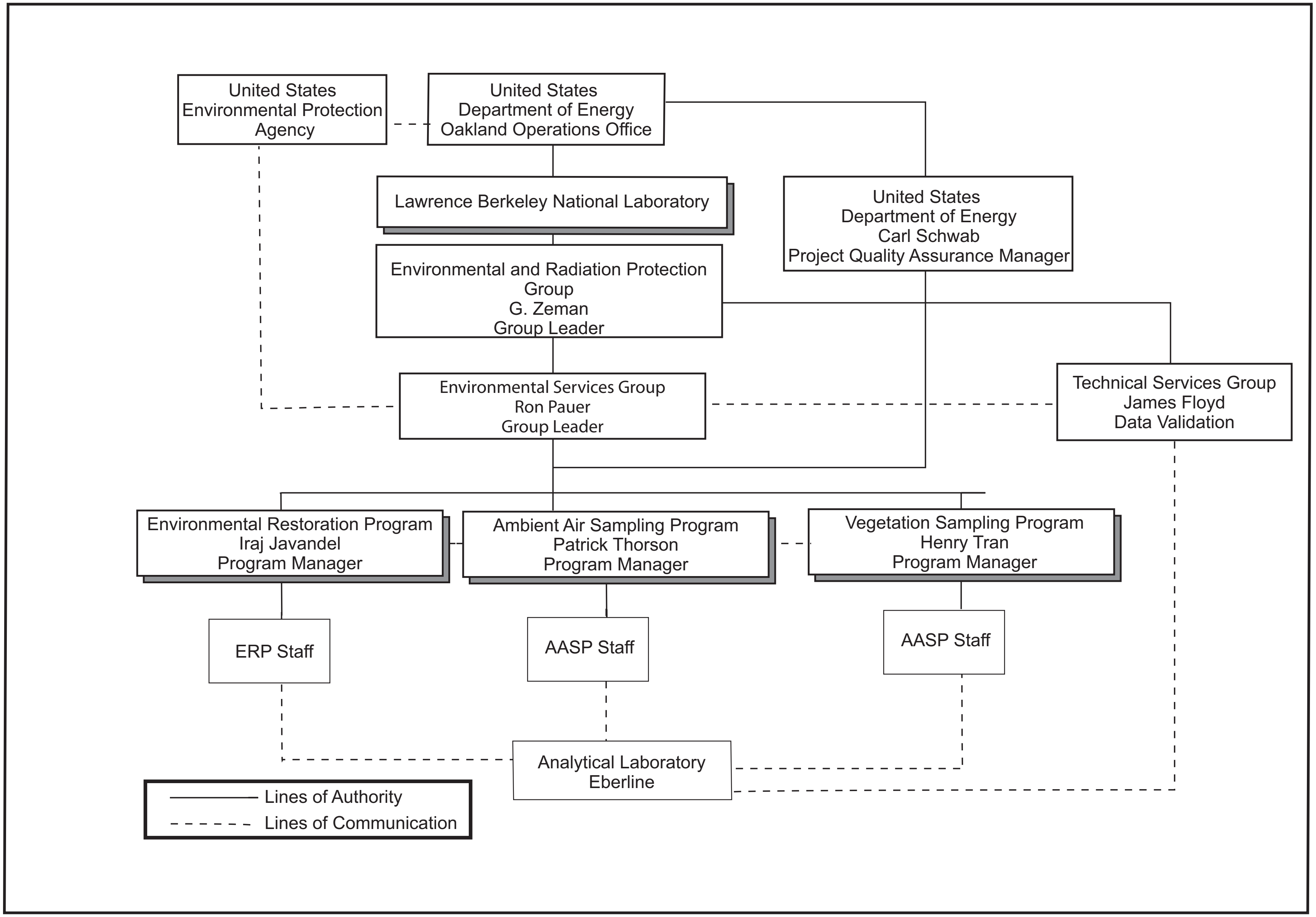

Figure 2.1. Organization Chart for EPA Requested Tritium Sampling

Environmental Restoration Program (ERP) Manager

The Environmental Restoration Program (ERP) Manager is Dr. Iraj Javandel. Dr. Javandel supervises all ERP activities and exercises project control over the pre-investigation, field investigation, data validation, and report writing activities performed by ERP staff. Dr. Javandel is responsible for initiating corrective action procedures when conditions adverse to the quality of soil, sediment, or surface water data collected under this QAPP are identified.

Ambient Air Sampling Program (AASP) Manager

The Ambient Air Sampling Program (AASP) Manager is Mr. Patrick Thorson. Mr. Thorson will oversee AASP activities from planning and site selection to data collection, analysis, and validation. Mr. Thorson is responsible for initiating corrective action procedures when conditions adverse to the quality of ambient air sampling data collected under this QAPP are identified.

Vegetation Sampling Program (VSP) Manager

The Vegetation Sampling Program (VSP) Manager is Ms. Linnea Wahl. Ms. Wahl oversees all VSP activities from planning and site selection to data collection, analysis, and validation. Ms. Wahl is responsible for initiating corrective action procedures when conditions adverse to the quality of vegetation sampling are identified.

Quality Assurance Manager (QAM)

The Quality Assurance Manager (QAM), Carl Schwab, is a DOE employee. He is responsible for reviewing and managing procedures described in the QAPP, conducting a Technical Systems Audit (TSA) for compliance with procedures specified in this QAPP, and reviewing data validation procedures. The QAM will conduct one TSA and prepare an audit report. The QAM will ensure that the need for corrective action measures indicated by assessment findings are communicated in writing to the ESG leader and the appropriate Program Manager, and will conduct and document follow-up of corrective action requests.

Samplers

Samplers will perform their activities under the technical direction of a Berkeley Lab environmental professional or a California Registered Geologist. Samplers will have the following minimum qualifications:

- Three years of environmental sample collection experience
- Demonstrated ability to collect samples using manual sampling techniques and to carry all necessary sampling equipment
- Demonstrated ability to successfully implement a sampling program under the technical supervision of Berkeley Lab staff
- For subsurface sampling, 40 hour OSHA training in hazardous waste operations as specified in 29 CFR 1910.120.

Data Validation

Mr. James Floyd of Berkeley Lab's Technical Services Group is responsible for conducting an independent review of the data. Mr. Floyd will review and validate a minimum of 10% of the data generated by the primary analytical laboratory.

Analytical Laboratories

Samples will be analyzed by laboratories that are certified/registered by the California Department of Health Services (DHS) as environmental testing laboratories for tritium. Eberline Services (formerly ThermoRetec Nuclear Services), the prime contractor for Berkeley Lab for radionuclide analysis, will analyze all primary samples. The Berkeley Lab's Radiation and Analytical Measurements Laboratory (RAML), a second laboratory to be determined, and a laboratory designated by EPA will analyze selected QC samples. EPA's designated laboratory will not be subject to the requirements of this QAPP

2.1.2 Data Users

This section discusses the roles of the principal data users. The data users include the regulatory agencies, the Environmental Sampling Project Task Force, and the Berkeley Lab programs that collect the data.

Regulatory Agencies

Under the scope of this QAPP, EPA will be the primary data user. EPA will use the data to support HRS scoring of Berkeley Lab.

DOE is the lead regulatory agency for areas of potential tritium contamination at Berkeley Lab and is responsible for reviewing work plans, sampling plans and deliverables, and for ensuring compliance with program requirements. EPA provides oversight and recommendations. EPA also assures compliance with NESHAP requirements. The San Francisco Bay Regional Water Quality Control Board (RWQCB) may provide recommendations if water quality objectives are impaired.

Environmental Sampling Project Task Force

The Environmental Sampling Project Task Force was formed in January 2000 in response to EPA's determination that Berkeley Lab was potentially eligible for its National Priorities List (NPL). As noted above, EPA recognized that existing tritium emissions were well below regulatory standards, but that additional sampling results would help the agency make its final listing decision. Its members include DHS, DOE, EPA; the Cities of Berkeley and Oakland, Berkeley Lab; and numerous advocacy, business, educational, health, neighborhood, and public interest groups. Data generated under this QAPP will be available to Task Force members.

Berkeley Lab Programs

Environmental Restoration Program

The ERP will compare the data obtained under this QAPP to those used in the Environmental Health Risk Assessment for Tritium Releases at the National Tritium Labeling Facility at Berkeley Lab (McKone, *et al.* 1997).

Ambient Air Sampling Program

The AASP will compare the ambient air data to results of EPA's CAP88 dispersion model. CAP88 software is used in annual compliance reporting to estimate ambient air concentrations and dose based on stack emissions and local meteorological data.

Vegetation Sampling Program

The VSP will also use the vegetation data to help characterize the presence of tritium in the environment and to provide data for dose assessment.

2.2 PROBLEM DEFINITION BACKGROUND

The National Tritium Labeling Facility

The largest source of tritium air emissions (greater than 99%) at Berkeley Lab is the National Tritium Labeling Facility (NTLF), which is located in Building 75. The NTLF was established as a National Institute of Health (NIH) national resource center in 1982. The facility's role is to conduct research and provide educational and tritium labeling support for biomedical researchers in North America. Tritium labeling is performed inside a closed system in glove boxes, which trap tritium to minimize its release to the environment. Tritium from fugitive losses in air drawn through the glove box ventilation system and the gaseous residual of tritiated water that is not trapped by the recovery system is directed through silica-gel traps and then primarily to the stack on the hillside west of Building 75 (Building 75 hillside stack). A smaller amount released from activities conducted in lab hoods is vented to another stack located on the roof of the building. The traps achieve greater than 98% collection efficiency. Berkeley Lab is investigating the feasibility of combining both stacks into one, which would be located on the roof of Building 75.

Tritium releases from the NTLF's stack are in the forms of tritiated water (HTO), gaseous tritium (HT), and some organically bound tritium (OBT). Historically, tritiated water, in the vapor form, accounted for over 90% of the releases and little OBT was released to the environment. Except for the NTLF and the Building 85 Waste Handling Facility, all other sources of tritium at Berkeley Lab are small (less than $3.7x10^{10}$ Becquerels [Bq];

$3.7x10^{10}$ Bq = 1 curie [Ci]) and contribute relatively little impact to the environment. During calendar year 1999, as reported in the *1999 Radionuclide Air Emission Annual Report for the Lawrence Berkeley National Laboratory* (Berkeley Lab, 2000), tritium emissions were $1.1x10^{12}$ Bq (30 Ci) from the NTLF, $9.3x10^{9}$ Bq (0.25 Ci) from the Building 85 Waste Handling Facility, and about $9x10^{6}$ Bq (0.0003 Ci) from all other sources.

Based on information provided by the DHS, there are 52 facilities in the vicinity of Berkeley Lab that are permitted to use radioactive material: 17 in Berkeley, 4 in Emeryville, and 31 in Oakland. Except for UC Berkeley, most of these are biomedical facilities that use very little tritium (less than $3.7x10^{10}$ Bq [1 Ci]). Based on information provided by UC Berkeley, its total tritium inventory is less than $5.6x10^{12}$ Bq (150 Ci). The annual tritium release from the stacks at UC Berkeley is less than $7.4x10^{8}$ Bq (20 millicuries [mCi]).

In 1997, Berkeley Lab completed a human health risk assessment that evaluated potential risk to workers and the public from exposure to tritium emitted from the NTLF (McKone et al. 1997). This risk assessment took into account an exposure to multiple media (air, soil, and water) and transfer of tritium between media (for example, air to soil, air to groundwater, and soil to groundwater). It also evaluated various exposure scenarios and exposure-point concentrations, based on modeled exposure concentrations. Results of the risk assessment indicated that the estimated dose to the public from the NTLF is well below the acceptable regulatory limit. Comparison of actual environmental data to the model results indicated that modeled values were slightly higher than measured values.

ESG Surveillance and Monitoring Programs

Soil, Sediment, and Surface Water Sampling

ERP investigations have included characterizing concentrations of tritium originating from NTLF activities in soil, sediment, surface water, and groundwater. Results of ERP investigations have been included in the Quarterly Progress Reports that are submitted to the regulatory oversight agencies (DTSC, City of Berkeley, RWQCB, City of Oakland, and DOE). Concentrations of tritium detected in soil have been orders of magnitude below the EPA Region IX Preliminary Remediation Goal (PRG) for residential soil. The PRG is the radionuclide's concentration in soil that generates a one in a million lifetime cancer risk. Results of soil, surface water, and sediment sampling conducted by the ERP are summarized in the Soil, Sediment, and Surface Water Sampling Plan for Tritium included in Attachment 1.

Air Monitoring

ESG collects air samples for tritium analysis as part of an ongoing, integrated, continuous monitoring program designed to assess the effects of radiological components in exhaust emissions and ambient air. Exhaust emissions monitoring systems measure airborne contaminants from the Building 75 hillside stack. The resultant dose estimated from these tritium emissions is well below the EPA's NESHAPs level as designated under applicable 40 CFR Part 61 regulations. This standard was set to protect public health with an ample margin of safety.

The AASP routinely collects samples of ambient air for analysis of tritiated water vapor at seven monitoring sites. Four of the sites are located on Berkeley Lab property, and three are on adjacent UC property. The placement of the sites was based on the location of the emission source, local wind patterns, and proximity to population centers. During the spring of 2001, LBNL will expand the network of routine sampling locations by adding six new sites. Four of the sites are located on site, and the remaining two are on adjacent UC property. The expansion will provide sampling coverage in directions from the NTLF that winds blow infrequently, giving a greater degree of assurance that tritium would be detected under any meteorological conditions in the event of an accidental release. Figure 2.2 shows both the existing and expanded sampling locations. Throughout the remainder of this report, reference to the routine network will assume both the existing and expanded sampling sites for a total of thirteen locations.

The sampling methodology at each site in the monitoring network consists of continuously collecting a sample of air moisture onto silica gel in a glass column, with the silica gel samples changed out and analyzed monthly for HTO. Sampling media consists of

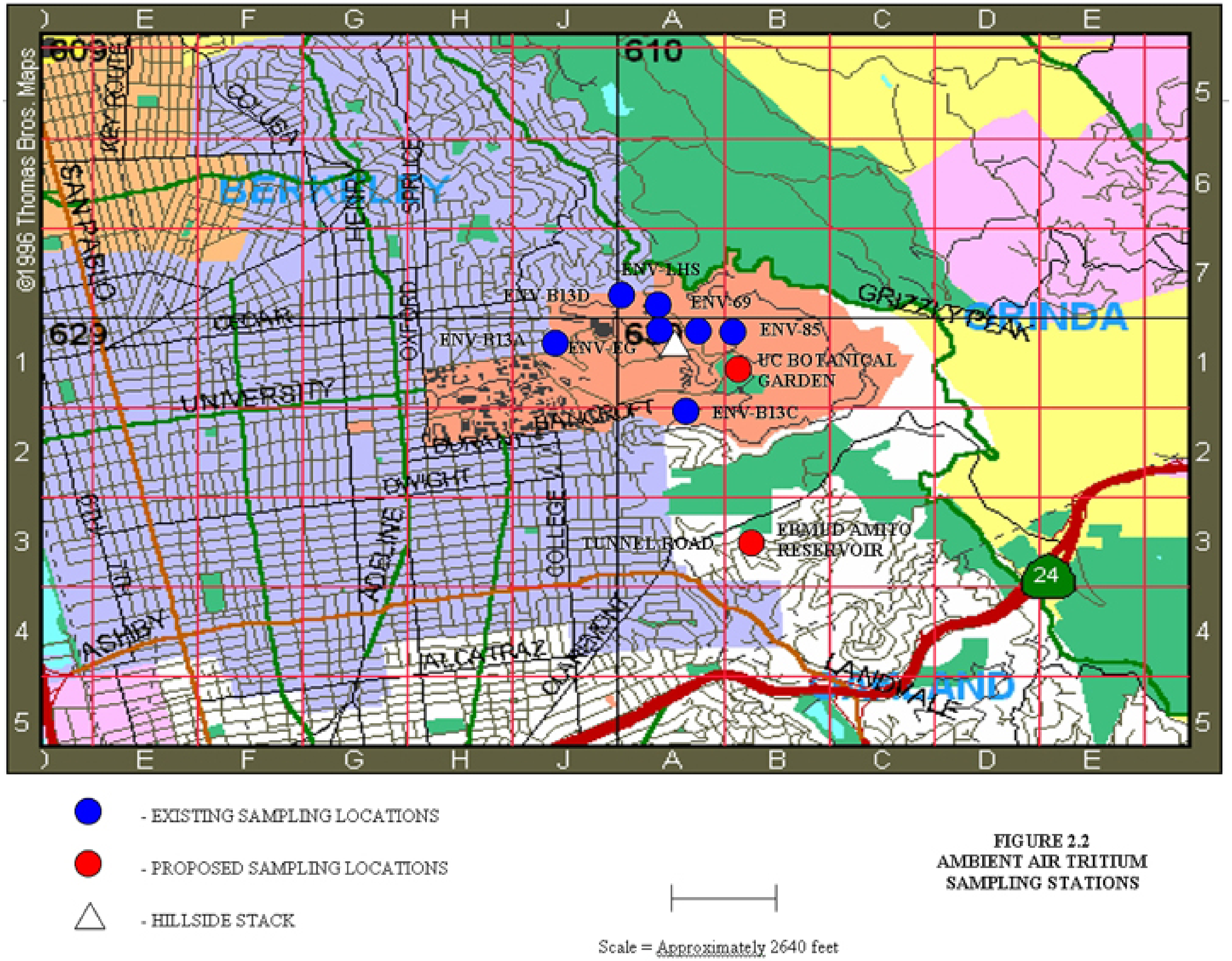

FIGURE 2.2
AMBIENT AIR TRITIUM
SAMPLING STATIONS

color indicating silica gel that captures the vapor bound tritium in the atmosphere as the air flows through the collection column. Results of the AASP are included in the Berkeley Lab's annual Site Environmental Reports. Recent annual ambient air monitoring information is included in the Ambient Air Sampling Plan for Tritium in Attachment 1. A wind rose, illustrating the wind direction and wind speeds for the period 1994 through 2000, is shown on Figure 2.3.

Dose assessments following EPA-required protocol are performed annually to estimate the risk to human health from tritium emissions from the NTLF, as well as all other release points of radionuclides. Results to date indicate that the estimated dose to the public from the NTLF is less than 5% of the EPA limit. Results of dose assessments are included in the annual Site Environmental Reports.

Vegetation Sampling

Tritiated water vapor released to the environment from the Building 75 hillside stack mixes and exchanges with atmospheric moisture, such as humidity, rain, and fog and other sources of environmental water such as plant water, surface water, and soil water. Within plants, tritium can occur either as tissue free-water tritium (TFWT) or organically bound tritium (OBT). TFWT is free-water tritium, where the tritium atom is part of a water molecule. Organically bound tritium consists primarily of tritium that is chemically bonded to organic compounds such as cellulose and sugars. As part of its surveillance responsibilities, the ESG collects vegetation samples to characterize the distribution of tritium in local vegetation. Results of vegetation sampling are included in the annual Site Environmental Reports.

In 1998 and 1999, samples were collected from trees, leaves, and duff (organic matter at the base of trees and shrubs) surrounding the Building 75 hillside stack. Results of these samples showed that tritium concentrations in vegetation decreased rapidly with increasing distance from the hillside stack. At about 150 to 200 meters (492 to 656 feet) from the stack, TFWT and OBT concentrations were near background levels (Pauer 1999). Dose assessments for various pathways of exposure indicated that there was no significant health

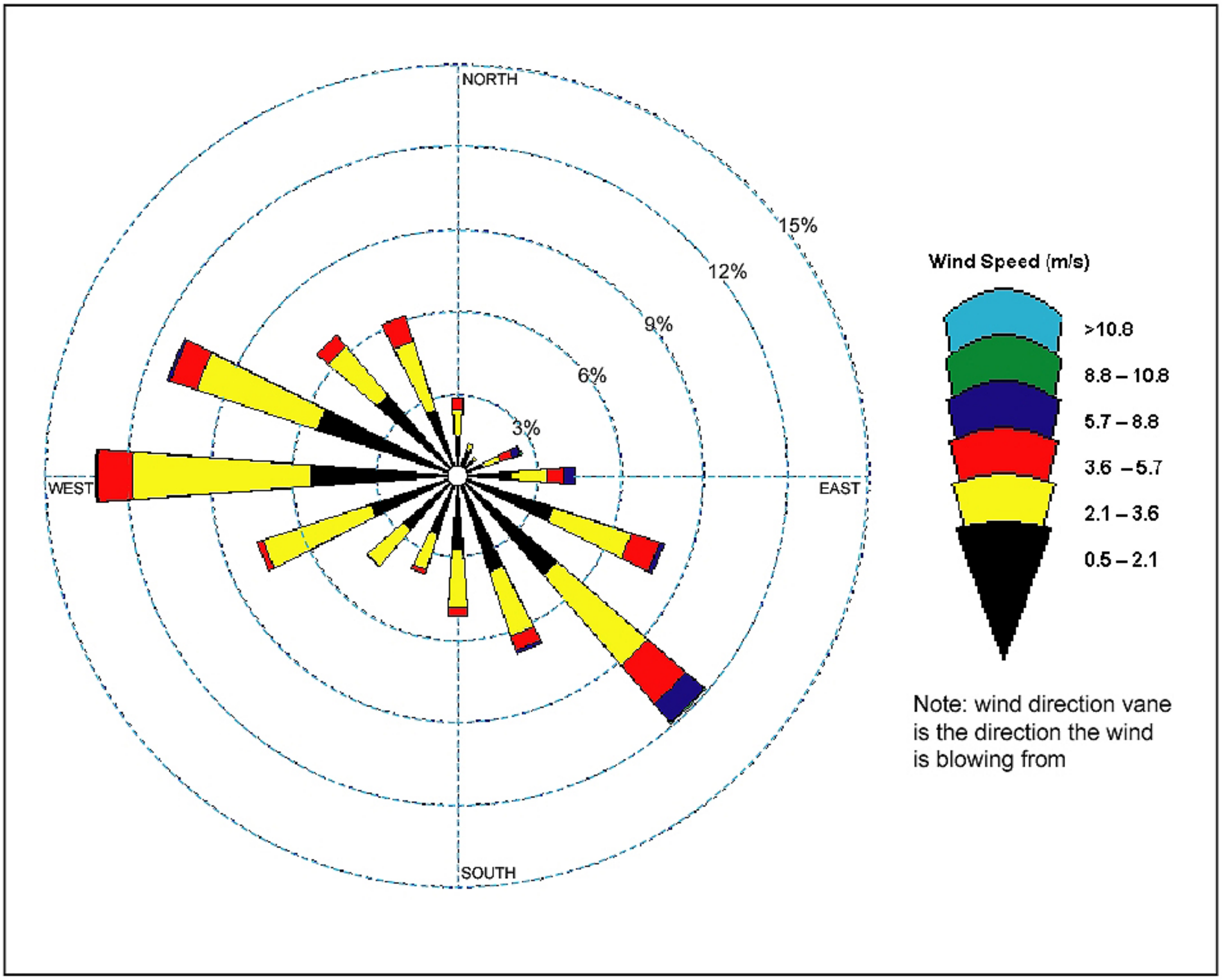

Figure 2.3 Windrose for Berkeley Lab - January 1994 thru December 2000

risk because the potential off-site doses were well below $1x10^{-6}$ sieverts (0.1 millirem [mrem]). Comparison doses included the NESHAPs standard established to protect public health from airborne exposure of $1x10^{-4}$ sieverts/year (10 mrem/year) and CFR, Chapter 10, Section 20 for all pathways of $1x10^{-3}$ sieverts (100 mrem/year).

<u>EPA's Request for Supplemental Information</u>

EPA issued its Superfund Evaluation Report in July 1998, with a preliminary finding that although Berkeley Lab is potentially eligible for the Superfund list, it would not be included at that time, because tritium emissions at the NTLF are well below national public health standards set under 40 CFR Part 61. In its letter to DOE dated September 3, 1998, however, EPA requested the following supplemental information be collected before it could complete its final Superfund listing decision for the Berkeley Lab site:

- Soil sampling for tritium within 0.8 kilometers (0.5 miles) of the Building 75 hillside stack to sufficiently delineate any areas contaminated with tritium
- Surface water and sediment sampling for tritium
- Ambient air sampling for tritium to determine if areas previously not covered by sampling stations, but within EPA's target distance category criteria for Superfund review, show contamination.

In addition, EPA has indicated that vegetation samples should also be collected for tritium analysis because of concerns expressed by the community. Berkeley Lab will therefore collect samples of vegetation and plant-transpired water to more fully characterize the magnitude and extent of tritium in the environment. Although these data are not included in the HRS scoring process, the data can be used to evaluate potential risks to human health and the environment.

2.3 PROJECT TASK DESCRIPTION AND SCHEDULE

<u>Soil, Sediment, and Surface Water Sampling</u>

Descriptions of the work to be performed and preliminary schedules are contained in the Soil, Sediment, and Surface Water Sampling Plan for Tritium included in Attachment 1.

Ambient Air Sampling

EPA requested in its letter of September 3, 1998 that ambient air samples be collected at additional locations. Two additional locations have been selected to comply with EPA's request (see Figure 2.2). A description of the work to be performed and preliminary schedule are contained in the Ambient Air Sampling Plan included in Attachment 1.

Vegetation Sampling

A description of the work to be performed and preliminary schedules are contained in the Vegetation Sampling Plan for Tritium included in Attachment 1.

2.4 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

The data quality objectives (DQOs) process is a series of planning steps that are designed to ensure that the type, quantity, and quality of environmental data used in the decision making process are appropriate for the intended application (EPA 1999). DQOs are the qualitative and quantitative statements derived from the outputs of each step of the DQO process that:

- Clarify the study objective
- Define the most appropriate type of data to collect
- Determine the most appropriate conditions from which to collect the data
- Specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support the decision.

DQOs are used to develop a scientific and resource-effective sampling design. The process consists of seven sequential steps, which are discussed in the following sections. This QAPP has been prepared to reflect the DQO process.

Step 1 - State the Problem: Summarize the contamination problem that will require new environmental data and identify the resources available to resolve the problem.

Tritium released from the NTLF is deposited in the surrounding environment by atmospheric dispersion, rainfall, and other depositional phenomena in the area surrounding the hillside stack. Exposure to environmental media that have been contaminated with tritium could potentially present a health risk to workers and the public, or could adversely affect the environment.

Berkeley Lab has performed a human health risk assessment that evaluated the risk to workers and the public that may result from exposure to tritium emitted from the Building 75 hillside stack. Results of the risk assessment indicate that the estimated dose to the public from the NTLF is well below the acceptable regulatory limit. Comparison of the model results to environmental data indicated that modeled values were slightly higher than measured values.

Soil

Tritium has been detected in soil samples collected in the area of Building 75. These samples have been collected at locations that have the greatest potential to contain the highest concentrations of tritium. Concentrations of tritium detected have all been approximately two orders of magnitude or more below the PRG for residential soil of 4.07×10^2 Bq/g (11,000 pCi/g). About 100 individual samples have been collected (composite samples have also been collected) from the upper 1.0 meters (3.5 feet) of soil within 152 meters (500 feet) of the Building 75 hillside stack and 10 samples from the upper 1.0 meter (3.5 feet) at distances greater than 152 meters (500 feet). Approximately 55 of these shallow samples were collected in the upper 0.6 meters (2 feet) of soil (the depth interval required for HRS scoring). The number of samples collected in the upper 0.6 meters (2 feet) of soil in sectors of circles at various distances from the Building 75 hillside stack are shown on Figure 2.4. The maximum concentration of tritium detected in soil has been 6.55 Bq/g (177 pCi/g) at a depth of 1.5 meters (5 feet) about 30.5 meters (100 feet) southeast of the stack. The maximum concentration of tritium detected within the upper 1.0 meter (3.5 feet) of soil has been 5.03

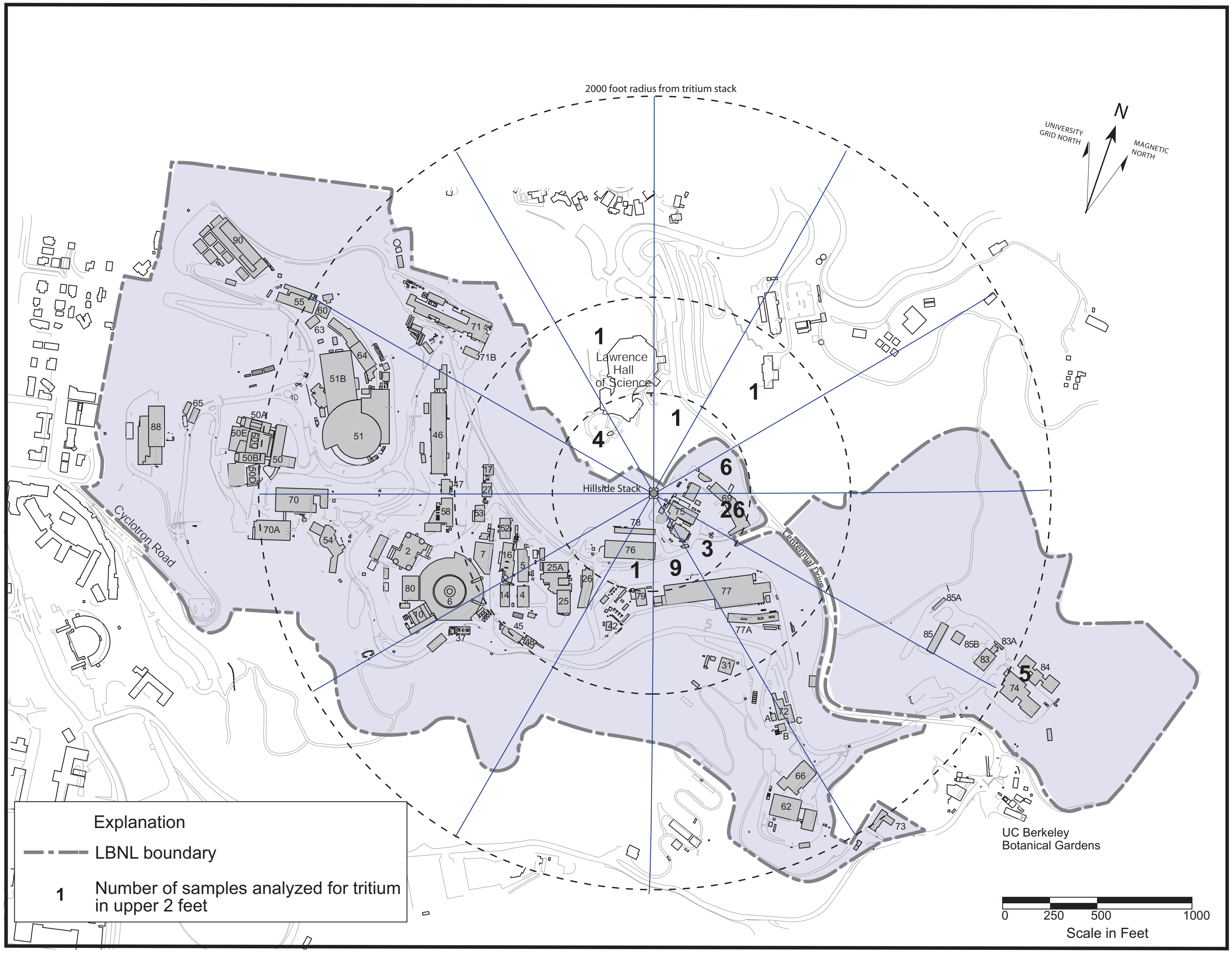

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Figure 2.4. Number of Shallow Soil Samples (, 2 feet) Analyzed for Tritium

Bq/g (136 pCi/g), at a depth of 0.15 meters (0.5 feet) near the same location. Concentrations detected have generally been one to two orders of magnitude lower than the maximum values detected, with a median value of 1.3×10^{-1} Bq/g (3.5 pCi/g) and an arithmetic mean of 3.07×10^{-1} Bq/g (8.3 pCi/g).

As noted above, the majority of soil samples that have been collected for tritium analysis were located near Building 75. The EPA has requested that additional soil samples be collected in accordance with HRS scoring requirements for the soil pathway, in order to sufficiently delineate any areas contaminated with tritium, in accordance with HRS scoring requirements.

Sediment and Surface Water

Surface runoff is conveyed from the developed areas of the site via a stormwater drainage system that connects to North Fork Strawberry Creek and to several minor tributaries of Strawberry Creek south of the site. Surface runoff from the major portion of the area where tritium contamination has been detected in the soil and potentially contaminated runoff from paved areas near Building 75 are directed to Chicken Creek (a tributary of Strawberry Creek). Surface runoff from exposed areas of potentially contaminated soil and potentially contaminated runoff from paved areas near the Lawrence Hall of Science are directed to a 48-inch storm drain culvert leading to North Fork Strawberry Creek. Tritium has been detected in surface water samples collected from these two creeks (Chicken and North Fork Strawberry). Tritium was also detected in a composite sediment sample collected from Chicken Creek in 1993, but was not detected in five sediment samples from Chicken Creek in 1996. The EPA has requested that additional surface water and sediment samples be collected to provide data required for HRS scoring of the surface water pathway.

Surface water sampling results are discussed in more detail in the Soil, Sediment, and Surface Water Sampling plan for tritium. As discussed in the Plan there is a good correlation between concentrations of tritium detected in surface water samples from Chicken Creek and monthly rainfall.

Ambient Air

Berkeley Lab has detected tritium concentrations in samples collected in its ambient air that are consistent with the wind direction data summarized on Figure 2.3. As expected, the maximum concentrations are found in the immediate area of the Building 75 hillside stack. Sampling point ENV-75EG registered the highest monthly and annual concentration in the network with values of 5.07 Bq/m^3 [137 pCi/m^3] and 2.16 Bq/m^3 [58 pCi/m^3], respectively. This sampling location was added in January to gather information of expected concentrations within the eucalyptus grove that surrounds the hillside stack. The site is located approximately 20 meters (65 feet) north-northwest of the stack. Siting a station this near to a source does not conform to traditional siting criteria because of the significant influence of the trees. Nevertheless, the results to date show a consistent dropoff rate in the measured HTO concentration to the next nearest station and Berkeley Lab's traditional location of the maximally exposed offsite individual: ENV-LHS. There the maximum monthly and annual tritium concentrations for the year 2000 were 1.81 Bq/m^3 [49 pCi/m^3] and 0.70 Bq/m^3 [19 pCi/m^3], respectively. ENV-LHS lies in the downwind direction for predominate nighttime and storm-event winds at a distance of about 120 meters (400 feet) north-northwest of the stack. The other nearfield sampling location is ENV-69, which lies east of the Building 75 hillside stack in the downwind direction of the primary daytime windflow at a distance of about 140 meters (450 feet). The maximum monthly and annual tritium concentrations for ENV-69 for the same time period were 0.77 Bq/m^3 [21 pCi/m^3] and 0.45 Bq/m^3 [12 pCi/m^3], respectively.

As noted above, ENV-LHS corresponds to the NESHAP maximally exposed individual compliance receptor, which is the highest potential offsite exposure within the sampling network. Berkeley Lab performs annual dose assessments as required by the NESHAP regulation in 40 CFR Part 61. The annual dose assessments are included in the Berkeley Lab Annual Site Environmental Reports. The doses associated with both the maximum monthly and annual average tritium concentrations at all the sampling sites in the network are well below the NESHAP public dose limit of 10 mrem per year.

The primary purpose of the tritium AASP is to provide further confirmation that Berkeley Lab operations comply with EPA NESHAP regulations. Additionally, EPA has requested supplemental information to complete its Superfund evaluation. As part of this supplemental request, EPA has asked that ambient air samples be collected from a location not affected by emissions from the hillside stack; in other words, a background sample.

Vegetation

The primary purpose of the tritium VSP is to provide additional information to more fully characterize the magnitude and extent of tritium in the environment (duff, leaves, tree wood, and plant-transpired water).

Step 2 - Identification of the Decision: Identify the decision that requires new environmental data to address the contamination problem.

Soil

EPA has requested that additional data be collected to assess the extent of tritium contamination in the soil surrounding the Building 75 hillside stack as required for HRS scoring. Berkeley Lab proposes a two-tiered approach to collect the soil data required by EPA. Tier 1 samples be collected to assess (in combination with previous samples) the magnitude and extent of tritium contamination in the soil.

Based on results of the Tier 1 sampling, additional samples may be collected. The requirement to collect Tier 2 samples will be based on potential health risk and data needed for HRS scoring. The need for additional samples will be determined by comparing tritium concentrations detected to the decision point value. The decision point value will be set at (4.07×10^1 Bq/g [1,100 pCi/g]), which is 10% of the health-based benchmark level (10% of the PRG for residential soil). At sampling locations where the tritium concentration is less than the decision point, no further investigation will be performed. At sampling locations where the decision point value is exceeded, additional samples will be collected to assess the magnitude and extent of contamination above the decision point value. The need for additional samples will also be determined by evaluating whether the extent of contamination has been adequately assessed. Where tritium is detected at a concentration greater than the Reporting Limit (RL) of 7.4×10^{-3} Bq/g [0.2 pCi/g] in the farthest sample collected from the hillside stack in a 30 degree sector, additional sample(s) will be collected at greater distances in that sector to determine the extent of contamination. This sampling methodology will assure the collection of data required to assess the extent of soil contamination on site and the extent and Level of soil contamination offsite, which are required for HRS scoring of the soil pathway.

In order to address concerns of the City of Berkeley, ten point composite samples will be collected at eight of the sampling locations outside of the Berkeley Lab boundary between the Building 75 hillside stack and the Lawrence hall of Science. These samples will be collected in accordance with HASL-300 guidance from the DOE Environmental Measurement Laboratory.

Sediment and Surface Water

EPA has requested that additional surface water and sediment samples be collected for tritium analysis from Strawberry Creek downstream of Berkeley Lab and at the storm drain outfall to San Francisco Bay, to provide data required for HRS scoring of the surface water pathway. This sampling methodology would entail sampling locations with potential contributions of tritium from sources other than Berkeley Lab. Nevertheless, Berkeley Lab will collect surface water and sediment samples from the above noted locations as well as from creeks draining Berkeley Lab, prior to discharge to Strawberry Creek. The data will be collected to assess if the HRS target, San Francisco Bay, has been impacted by tritium releases from the NTLF.

Ambient Air

EPA has requested that additional ambient air sampling locations be added to the existing sampling sites to characterize the magnitude and extent of tritium emissions resulting from Berkeley Lab activities. Berkeley Lab proposes to collect continuous air samples (for tritium analysis) at two additional locations to complement the current routine station sampling configuration of thirteen sites.

Samples will be collected. The associated data will be used to analyze any potential health risks and to aid in HRS scoring. The annual tritium concentration is determined for each monitoring location by averaging the results for the 12 monthly samples. The alternative annual average compliance level for tritium set by NESHAPs is 55.6 Bq/m^3 (1500 pCi/m^3). This alternative value is used when a facility chooses not to conduct stack sampling to gather the information needed for conduct a qualified dose assessment. In addition to comparing the annual concentration to the regulatory limit as required, Berkeley Lab will also compare individual monthly tritium concentrations to the regulatory limit.

Vegetation

Because of concerns expressed by the community and the HRS re-evaluation of Berkeley Lab by EPA, additional vegetation samples (duff, leaves, and tree wood) and samples of plant transpired water will be collected to more thoroughly characterize the extent of tritium contamination in the environment.

Step 3 - Identify the Inputs to the Decision: Identify the information needed to support the decision.

A checklist comparing HRS requirements with the proposed soil, surface water and sediment, and air sampling designs is included as Table 2.1.

Soil

Tier 1 soil sampling locations are specified in the Soil, Sediment, and Surface Water Sampling Plan for Tritium included in Attachment 1. Tier 1 investigations will consist of collecting and analyzing soil samples at 64 locations within approximately 610 meters (2,000 feet) of the Building 75 hillside stack. Soil samples will be collected within 0.6 meters (2 feet) of the surface, as required for HRS scoring. Samples will be collected at two depth intervals at each sampling location: from 0.15 to 0.3 meters (0.5 to 1 foot) and 0.45 to 0.6

Table 2.1 Checklist Comparing HRS Requirements with Sampling Design

Factor	HRS Objective	Consideration	Target	Is Proposed Sampling Designed to Achieve HRS Objective?
Soil Exposure Pathway				
Likelihood of Exposure	Determine area of observed contamination			Yes
Waste Characteristics	Determine hazardous waste quantity (consider only upper two feet of soil).			Yes
Targets	Determine targets exposed to contamination.	Is contamination within 200 feet of a residence?	Resident Individual	Yes
		Is contamination within 200 feet of a workplace?	Workers	Yes
		Is contamination within 200 feet of a school?	Students	Yes
	Determine level of contamination.	Is concentration at or above benchmark?		Yes
Surface Water Pathway Human Food Chain Threat				
Targets	Determine targets exposed to contamination and level of contamination.	Is concentration at or above benchmark?	Fishery (San Francisco Bay)	Yes
Air Pathway			(Target Distance)	
Targets	Determine targets exposed to contamination and level of contamination.	Is concentration at or above benchmark?	0 to 1/4 mile	Yes
			>1/4 to 1/2 mile	Yes
			>1/2 to 1 mile	Yes
			>1 mile to 2 miles (background)	
			>2 to 3 miles	NA
			>3 to 4 miles	NA
				NA: Not applicable based on available monitoring data.

meters (1.5 to 2 feet), to address the potential variation in tritium concentration within the top 2 feet of soil due to seasonal variations in moisture content in the near surface soil profile.

The proposed sample pattern was based on the following criteria:

- The stack is a point source
- In the absence of wind, the distribution of emissions is radially outward
- In the presence of wind, the emissions will be carried downwind and dispersed horizontally and vertically with downwind distance from the source
- The principal wind directions are toward the east (daytime) and toward the northwest (evening and storm events).

To address the above criteria, a radial pattern was established with three concentric rings at distances of 152, 305, and 609 meters (500, 1000, and 2000 feet) from the hillside stack. The rings were segmented into 36 elements with radii at 30° intervals. One soil sample will be collected from each element, as close to the center of the element as possible. Six additional samples will be collected at distances of approximately 609 meters (2000 feet) in the predominant wind directions. Four samples will also be collected in a rectangular pattern at distances of approximately 7.6 meters (25 feet) from the base of the hillside stack. Ten additional samples will be collected in the primary wind direction near the Lawrence Hall of Science. These samples will be collected to obtain additional information in areas that are accessible to the public. In response to a recommendation from the EPA, samples will be collected at eight additional sampling points in the vicinity of the hillside stack and in the area between the stack and the Lawrence Hall of Science, where existing data show elevated tritium concentrations in the soil. These samples will be used to determine whether the data collected is adequate for HRS scoring and no further investigation is warranted or whether there is a need for the collection of additional data.

Sediment and Surface Water

Sediment and surface water samples will be collected from North Fork Strawberry Creek, seven tributaries of Strawberry Creek, and two locations along Strawberry Creek, as specified in the Soil, Sediment, and Surface Water Sampling Plan for Tritium included in

Attachment 1. Samples will be collected at each sampling location during two independent sampling events, once during the rainy season and once during the dry season. In addition, surface water samples will be collected monthly during the rainy season from Chicken Creek, North Fork Strawberry Creek, and Strawberry Creek from October through March.

Background surface water samples will be collected from Lake Anza and Lake Temescal, which are outside the area influenced by the site.

Ambient Air

EPA has requested that ambient air samples be collected at additional locations as part of the AASP. The locations of the thirteen routine and two proposed supplemental tritium ambient air sampling points are shown on Figure 2.2. The annual wind pattern diagram, which is illustrated on Figure 2.3, indicates two most frequent wind directions occur at Berkeley Lab. The most frequent wind direction is with winds blowing from the west-northwest. The second most frequent wind direction is with winds blowing from the southeast. The most frequent wind direction typically occurs as a result of daytime winds, whereas the second highest directional winds take place during nighttime and storm-event situations.

The ambient air sampling network currently includes two stations downwind of the Building 75 hillside stack in the predominant daytime windflow direction; a rooftop site (ENV-69) at Building 69, about 140 meters (450 feet) east of the stack, and a ground-level site (ENV-85) near Building 85, about 550 meters (1,800 feet) southeast of the hillside stack. To assess downwind impacts in the second most frequent wind direction, Berkeley Lab has a series of three ground-level stations. The first station is within the eucalyptus grove (ENV-75EG) about 25 meters (75 feet) north-northwest of the hillside stack. The second station is also in this same downwind direction at the Lawrence Hall of Science (ENV-LHS), about 120 meters (400 feet) from the hillside stack. The third station is at monitoring shack 13D (ENV-13D), approximately 460 meters (1,500 feet) northwest of the stack. Just beyond location ENV-13D, a residential region begins that borders the northern property line of Berkeley Lab. The two other existing locations, ENV-13A and ENV-13C, are not in the primary or secondary wind directions and historically display much lower (i.e., at or below analytical detection limits) ambient air concentrations of tritium. ENV-13A is approximately 840 meters (2,750 feet) west of the stack, and ENV-13C approximately 1,000 meters (3,300 feet) south of the stack. The six newly-added sites in the routine network are all located in directions from the hillside stack in which the wind infrequently blows. These sites, referred to as ENV's -31, -44, -77, -78, -MSRI, and –SSL, are situated at varying distances from the stack, though all are as close to the NTLF as a station can practicably be sited in the chosen direction. See Figure 2.2 for more details on exact locations.

Wind direction, along with proximity to populated areas, provide additional information on the appropriate placement of sampling sites within the network. Based on knowledge of tritium emission sources, current sampling locations, and the local meteorological conditions, Berkeley Lab is proposing two additional sampling locations be added to the AASP network to comply with EPA's requests for supplemental monitoring. The proposed locations will provide ambient air data downwind of the stack in the two most predominant wind directions in areas where data were previously extrapolated from the existing monitoring network.

The first proposed site is within the UC's Botanical Gardens. The selected site is approximately 950 meters (3,100 feet) southeast of the stack (see Figure 2.2). This location was chosen to obtain additional information on concentrations of tritium in the ambient air in the primary wind direction downwind of the stack. The base elevation of the site decreases from 320 to 245 meters (1,050 to 800 feet) in traveling along the radial line from Building 69 to Building 85 to the Botanical Gardens. The area to the east and south of the Botanical Gardens is a sensitive ecological study area managed by the University of California. This study area is less desirable as a sampling location than the Botanical Gardens because of the greater distance from the source and absence of infrastructure to support the sampling.

EPA has also requested one location far enough from the Building 75 hillside stack to be representative of background conditions. The proposed location to satisfy this request is at East Bay Municipal Utility District's Amito Reservoir. This site is about 2,300 meters (7,500 feet) south-southeast of the hillside stack. Base elevations at the stack and at Amito

Reservoir are nearly identical, although a lower canyon floor and higher ridge line fall between these two locations. The terrain, meteorological conditions, and vegetation at Amito Reservoir is very similar to that found at Berkeley Lab. The background concentration of tritiated water in ambient air in northern California is estimated to be approximately 0.004 to 0.015 Bq/m^3 (0.1 to 0.4 pCi/m^3).

Vegetation

The inputs to the decision include the concentrations of tritium in vegetation (duff, leaves, and tree wood) and in plant-transpired water in samples collected from trees surrounding the NTLF. The data will be collected and analyzed in accordance with EPA Superfund QA/QC requirements.

Step 4 - Define the Boundaries of the Site: Specify the spatial and temporal aspects of the environmental media that the data must represent to support the decision.

Soil

The boundaries of the site are defined as the upper 2 feet of soil within 610 meters (2,000 feet) of the hillside stack at Building 75. This is the volume of soil most likely to show an impact from recent aerial deposition of tritium from the stack. It is also the layer of soil to which people are most likely to be exposed and the depth required for HRS scoring. The spacial extent will be extended radially if tritium is detected in the farthest sample collected in any 30-degree sector at a concentration above the RL.

Berkeley Lab proposes to collect samples as close as possible to the locations indicated in the Sampling Plan included in Attachment 1. However, because of the steep terrain (e.g., in the southern sectors) and the residential nature of some of the sampling locations (e.g., those in the northern sectors) actual sampling points may be moved. If sampling access is difficult or denied (by residents) sampling locations will be relocated within the same sector and distance range from the stack. The EPA requested soil sampling conducted in accordance with requirements of this QAPP is a one time sampling event.

Sediment and Surface Water

Surface water and sediment samples will be collected from creeks that carry runoff from Berkeley Lab and at the outfall of Strawberry Creek to San Francisco Bay, if the location is accessible. The following creeks will be sampled:

- North Fork Strawberry
- Banana
- Pineapple
- Cafeteria
- Chicken
- No Name
- Ten Inch
- Ravine
- Strawberry.

The concentration of tritium in surface water is a function of several factors including facility activity, and rainfall intensity and duration. Based on a review of data collected from 1997 to 1999, there is a good correlation between total monthly rainfall and tritium concentrations detected in surface water samples from Chicken Creek. The minimum concentration occurs at the end of the dry season (September) and the maximum concentration during the maximum rainfall period. The sampling is designed to assess the time variation in the concentration of tritium in the surface water. Sediment and surface sampling will be carried out over a period of one year.

Ambient Air

The spatial boundaries of the study area are defined as a radial distance of 3.2 kilometers (2 miles) from the hillside stack at Building 75. The CAP88 dispersion model provides a good correlation between modeled tritium values within the site boundaries and data from existing sampling locations. The maximum distance at which tritium- emissions are likely to be detected is approximately 760 meters (2,500 feet); however, the study boundary extends to 3.2 kilometers (2 miles) from the source to enable the collection of background samples. This additional distance also allows for additional and continuous sampling coverage of the area's most sensitive receptors, and will provide a basis for HRS scoring.

Vegetation

The spatial boundary of study covers the area of potential direct impact from NTLF's tritium emissions. The spatial boundary of vegetation sampling is similar to the spatial boundary for the air sampling, for comparison purposes. Eight locations were selected for sampling wood chips, leaf, and duff and three locations for sampling plant-transpired water. Wood chips, leaf, duff, and plant-transpired water will also be sampled at Chabot Park, a location not affected by emissions from the Building 75 hillside stack (background). The locations proposed for sampling are shown in Table 2.2 and are depicted on Figure 2.5. The locations were selected based on primary transport mechanisms (wind direction and precipitation) and the locations of topographic barriers to tritium distribution.

The temporal boundary for the vegetation sampling is one year, with samples tentatively scheduled for collection between March and December of 2001. Samples will be collected at two times during the year to observe seasonal variations.

Table 2.2. Proposed Vegetation Sampling Locations

Location Number	Direction	Distance from Building 75 Hillside Stack (Meters)	Comments
NNW1	NNW	20	Vicinity Lawrence Hall of Science
NNW2	NNW	100	Vicinity Lawrence Hall of Science
NNW3	NNW	300	Vicinity Lawrence Hall of Science
WNW4	WNW	100	Vicinity Lawrence Hall of Science
NNN5	N	50	Vicinity Lawrence Hall of Science
EEE6	E	200	Site boundary in predominant wind direction.
SSE7	SSE	600	Directly opposite compass direction of Samples 1 through 4
WWW8	W	850	Directly opposite compass direction of Sample 6
NWW9	NW	20,000	Proposed background sample
NNW1-Dup	NNW	20	Field duplicate at Location No. NNW1

Note: Samples of transpired water will also be collected at locations NNW1, NNW2, NNW3, NWW9, and NNW1-Dup.

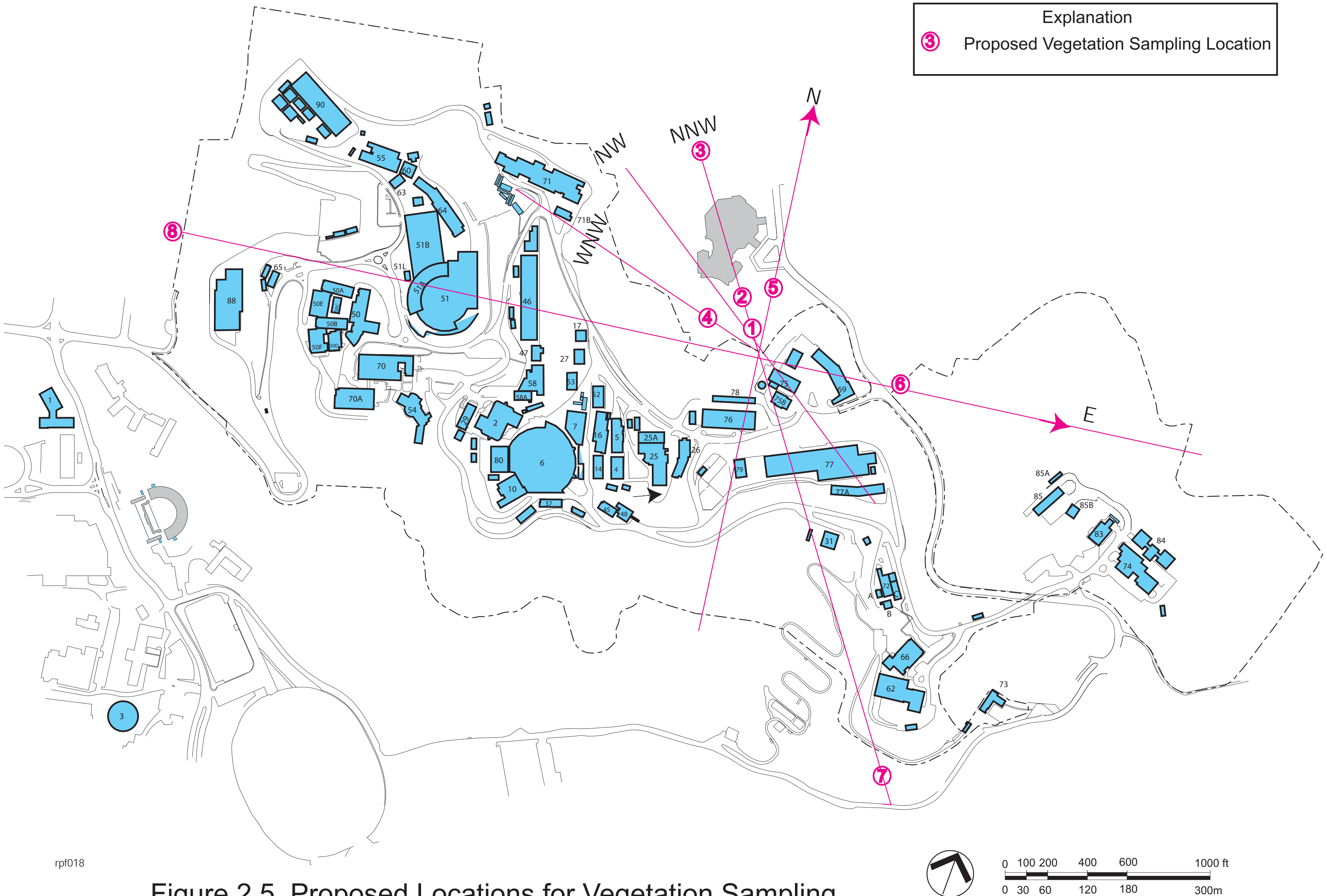

Figure 2.5 Proposed Locations for Vegetation Sampling

<u>Step 5 - Develop a Decision Rule: Develop a logical "if...then..." statement that defines the conditions that would cause the decision maker to choose among alternative actions.</u>

Soil

If the tritium concentration does not exceed one-tenth of the benchmark level (Region IX PRG for Residential Soil) in a single sample and if tritium is not detected above 7.4×10^{-3} Bq/g (0.2 pCi/g) in the farthest sample collected from the Building 75 hillside stack in each 30 degree sector, then no further investigation will be performed.

If tritium is detected at a concentration above 41 Bq/g (1,100 pCi/g) (one-tenth of the EPA Region IX PRG), then a minimum of four additional samples will be collected within 30.4 meters (100 feet) from locations where the decision point value is exceeded, until the extent of soil contamination above 41 Bq/g (1,100 pCi/g) has been characterized. Where tritium is detected at a concentration above 7.4×10^{-3} Bq/g (0.2 pCi/g) in the farthest sample collected from the Building 75 hillside stack in any 30 degree sector, two additional samples will be collected at greater distances in that sector to determine the radial extent of tritium above 7.4×10^{-3} Bq/g (0.2 pCi/g).

Sediment and Surface Water

If tritium is detected in the surface water samples collected from Strawberry Creek or at the outfall to San Francisco Bay at a concentration greater than the benchmark of 6.6×10^{3} Bq/L (1.8×10^{5} pCi/L), the source of the tritium will be evaluated. The benchmark is the 10^{-6} risk for persons swimming or wading in the creek and is a more conservative value than the risk to wildlife. In addition, if there is a non-routine release of tritium during a period of rainfall, additional surface water samples will be collected at all the sampling locations.

Ambient Air

The ambient air-monitoring network provides an additional check on the environmental impacts of tritium emissions from Berkeley Lab operations beyond the required dose assessment evaluations under NESHAPS. No single ambient air sample or annual average should exceed the NESHAP dose standard ($1x10^{-4}$ sieverts/year [10 millirems/year]). If a monthly sample or annual average concentration is found to contain tritium levels exceeding 1.8 Bq/m^3 (50 pCi/ m^3), Berkeley Lab will confirm the results with split sample analysis and other QC data, as well as investigate the cause of the elevated results.

Vegetation

If the results of the vegetation sampling indicate either a larger areal distribution or greater concentration of tritium in vegetation than what has been previously measured, additional samples may be collected.

Steps 6 and 7 - Specify Limits on Decision Errors: Specify the decision maker's acceptable limits on decision errors, which are used to establish appropriate performance goals for limiting uncertainty in the data (Step 6). Optimize the Design: Identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs (Step 7).

Soil

Existing soil data and modeled environmental concentrations of tritium indicate that concentrations of tritium are well below health-based exposure thresholds (i.e., the Region IX PRG for tritium in residential soils). In addition, a human health risk assessment and the results of worker urinalysis have indicated that potential exposures and the resulting dose to people working and living near the hillside stack do not represent a public health threat. In spite of this information, some data gaps exist regarding tritium concentrations in the soil associated with NTLF operations. The EPA has requested that additional soil samples be collected to determine the extent of this impact.

Two criteria were established to determine when additional (Tier 2) soil samples would be required, potential health risk and data needed for HRS scoring. The exceedence of the health-protective decision point value of one-tenth the PRG for tritium in one sample or the detection of tritium in excess of $7.4x10^{-3}$ Bq/g (0.2 pCi/g) in the farthest sample collected from the hillside stack in each sector will trigger a second tier of action. This approach assures that the potential for adverse public health consequences or inadequate data for HRS scoring (Type I error) is minimized. In addition, the use of the two-tiered approach minimizes the number of samples required to meet the DQOs.

Surface Water and Sediment

Analytical errors will be minimized by implementing QA practices described in this QAPP. By following the requirements of this QAPP, valid surface water and sediment data will be collected to aid in HRS scoring. The surface water and sediment sampling has been designed to be the most resource effective for generating the data required for HRS scoring.

Ambient Air

Existing ambient air data and modeled tritium concentrations indicate that tritium releases from Berkeley Lab are well below health-based exposure concentrations associated with the NESHAPs standard. In addition, a human health risk assessment and the results of worker urinalysis have indicated that potential exposures and the resulting dose to people working and living near the hillside stack are below regulatory concern. Nevertheless, some data gaps exist in measuring the levels of ambient air tritium in the vicinity of Berkeley Lab's Building 75, specifically at certain critical distances from the stack necessary for EPA to complete their HRS scoring evaluation.

Data collected from the existing and proposed ambient air sampling locations will be used to refine HRS scoring. If the health-protective decision-point value for tritium is exceeded in one sample, Berkeley Lab will analyze split samples to confirm the results and evaluate the validity of the data.

Vegetation

Analytical errors will be minimized by implementing QA practices described in this QAPP. Analytical errors will be assessed and supported through the defined documentation requirements described in this QAPP.

2.5 SPECIAL TRAINING REQUIREMENTS

Field personnel must have job-specific training to collect samples and operate sampling equipment in accordance with requirements of this QAPP. The Berkeley Lab Operational Health Physics Group will be notified when sampling personnel will be working near the hillside stack. Field personnel working near the stack will have Berkeley Lab general employee radiation training, which is required of all Berkeley Lab personnel.

2.6 DOCUMENTATION AND RECORDS

The documentation and records that apply to this project include field operation records; analytical laboratory records; a technical systems audit report; and reports of results. A description of the documentation and records follows.

Field Operations Records

Documentation requirements for collection and handling of soil, sediment, surface water, ambient air, and vegetation samples are specified in the following Berkeley Lab Standard Operating Procedures (SOPs), which are included in Attachment 3 for soil, sediment, and surface water sampling and Attachment 4 for ambient air and vegetation sampling:

- ERP SOP 1.3 Soil Sampling
- ERP SOP 2.2 Water Sampling
- ERP SOP 4.1 Sample Control and Documentation
- EH&S Procedure 261 Ambient Air Sampling and Calibration Procedure
- EH&S Procedure 268 Environmental Sample Tracking and Data Management Procedure
- EH&S Procedure 267 Vegetation Sampling Procedure
- Supplement to EH&S Procedure 267 Sampling Method for Plant-Transpired Water
- EH&S Procedure 268 Environmental Sample Tracking and Data Management Procedure.

The SOPs specify the protocol for sampling and the information required for completing the following documentation and records:

- Field logbook
- Sampling Data Sheet or Sample Collection Form
- Sample labels
- Chain of Custody Form
- Calibration Log Sheet (for ambient air sampler).

Laboratory Records

The analytical laboratory will be responsible for preparing reports summarizing the results of analysis and for preparing detailed data packages that include all information necessary to perform data validation. An example data package is included as Attachment 10.

The following quality control information will be included in the laboratory data packages:

- laboratory blank results
- laboratory control sample (LCS) results with calculation of percent recovery
- matrix spike/matrix spike duplicate (MS/MSD) results with calculation of percent recoveries and relative percent difference (RPD) of duplicate
- duplicate results with calculation of RPD.

In addition, every data report will contain the following information:

- results outside control limits
- corrective action and comments on variations such as poor detection limits or missing data
- a statement from responsible laboratory personnel that results do or do not meet quality acceptance criteria.

The original laboratory data packages will be maintained in the files of the ERP data manager (soil, sediment, and surface water samples) or the ESG data manager (air and vegetation samples). Analytical results will be entered into the ERP database (soil, sediment, and surface water samples) or the ESG environmental monitoring management system (air and vegetation samples).

The analytical laboratory will store unused sample materials for at least 60 days after the draft report of sampling results has been made available for external review.

Technical Systems Audit (TSA) Report

The Quality Assurance Manager (QAM) will perform one TSA of each of the three sampling programs (soil, sediment, and surface water; ambient air; and vegetation). The QAM will prepare a written report to the ESG Leader of results of his inspections, summaries of problems, and corrective action requests. The QAM will communicate the need for corrective action measures indicated by assessment findings in writing to the appropriate Program Manager.

Reporting of Results

Berkeley Lab will prepare a report for soil, sediment, surface water, ambient air, and vegetation sampling after data validation has been completed. The report will be submitted to DOE and EPA and will include the following:

- description of the methods used to collect the samples
- figure(s) showing sample locations
- table showing analytical results
- discussion of results
- assessment of data quality.

In addition, results will be reported in Berkeley Lab's Site Environmental Report(s) for the calendar year(s) in which the samples were collected.

Analytical results will be presented in tables that include the following information:

- Field sample and laboratory identification numbers
- Sample matrix

- Sampling depth (below ground surface) for soil and sediment
- Sampling coordinates (UC grid)
- Analytical laboratory that performed the analysis
- Sample collection date
- Sample analysis date
- Analytical results and associated units
- Qualifiers that are applied during verification and validation
- Reporting limits
- Decision point (results that are above the applicable decision point will be highlighted in bold font).

An aerial photograph of the site will be used as a base map for showing sampling locations and the spacial distribution of the analytical results. Areas covered with concrete, asphalt, etc. will be marked on the base map or as an overlay. Soil sampling locations that are within the limits of the aerial photograph will be presented on an overlay, with the corresponding sample reference number and results. A separate overlay will be provided for each of the two intervals that will be sampled (soil). Results will be contoured to illustrate spacial distributions, if appropriate. Results may also be color coded for different activity ranges. Topographic contours will be presented on a separate overlay. Air, surface water, and sediment sampling locations that are within the limits of the aerial photograph will be presented on a separate overlay, with the sample reference numbers indicated. Where sampling locations are not within the area of the base map, sampling locations will be shown on a topographic map of the site and surrounding area. The data presentation may be modified as appropriate to improve the effectiveness and usefulness of the data presentation.

SECTION 3

MEASUREMENT DATA ACQUISITION

Elements of measurement data acquisition include sampling process design, sampling method requirements, sample handling and custody requirements, analytical method requirements, quality control requirements, inspection calibration and frequency, inspection and acceptance criteria for supplies and consumables, data acquisition requirements, and data management. These elements are discussed in the following sections.

3.1 SAMPLING PROCESS DESIGN

The preliminary schedule, types and numbers of samples required, the design of the sampling network, the sample matrices, measurement parameters of interest, and the rationale for the design for soil, sediment, surface water, ambient air, and vegetation sampling are specified in Section 2.4 of this QAPP or in the sampling plans included in Attachment 1. Soil, sediment, surface water, and vegetation samples (including plant-transpired water) will not be collected on rainy or foggy days or immediately following a heavy rainfall, due to the potential for sample contamination and potential slip hazards for the samplers.

All measurements are classified as critical. If sampling locations must be modified or other changes in the sampling design are required by field constraints, the reason for the change will be documented in the field notebook.

3.2 SAMPLING METHODS REQUIREMENTS

Decontamination of sampling equipment will be conducted between each sampling location to minimize the potential for cross-contamination. Equipment intended for reuse that makes contact with potentially contaminated material will be decontaminated. Equipment will be decontaminated prior to daily sampling activities, between use, and at the conclusion of daily sampling activities to minimize the potential for cross contamination.

The wood augers used for tree wood chip sampling will be cleaned with a kimwipe. Soil, sediment, and surface water sampling equipment will be decontaminated as follows:

- Remove any solid particles from the equipment or material by brushing
- Rinse with tap water
- Place equipment on a clean surface in an uncontaminated environment. If the sampling equipment is not going to be used immediately, allow it to air dry for at least 15 minutes, then place it in a clean plastic bag or container for storage.

Sample methods requirements are specified in the following SOPs, which are included in Attachments 3 for soil, sediment, and surface water and Attachment 4 for ambient air, vegetation, and transpired water:

- ERP SOP 1.3 Soil Sampling
- ERP SOP 2.2 Water Sampling
- ERP SOP 4.1 Sample Control and Documentation
- ERP SOP 4.2 Sample Containers, Preservation, and Holding Time
- ERP SOP 4.4 Equipment Decontamination
- ERP SOP 4.5 General Instructions for Field Personnel
- EH&S Procedure 261 Ambient Air Sampling and Calibration Procedure
- EH&S Procedure 267 Vegetation Sampling Procedure
- Supplement to EH&S Procedure 267 Sampling Method for Plant-Transpired Water.

Any deviations from the SOPs will be documented in the field notebook and appropriate field form. The appropriate Program Manager is responsible for initiating corrective action procedures for any activities that may have an adverse effect on the data quality for this project. The holding time for tritium samples is 6 months.

The minimum sample volumes required for the various environmental media to be sampled are listed in Table 3.1.

Table 3.1. Minimum Sample Weight/Volume

Sample Matrix	Tritium Analysis	Minimum Sample Amount Required per Analysis	Approximate Amount to be Collected per Sample Submitted for Analysis	Container
Soil and Sediment	Free-Water Tritium	200 grams	500 grams	brass tube sealed with Teflon sheeting and high-density polyethylene caps and placed in a Ziploc plastic bag.
Soil and Sediment	Total Tritium	20 grams	500 grams	brass tube sealed with Teflon sheeting and high-density polyethylene caps and placed in a Ziploc plastic bag.
Surface Water or Plant Transpiration Water	Free-Water Tritium	50 ml	60 ml	60 ml glass bottle
Air moisture[a] absorbed on silica gel	Free-Water Tritium	20 ml of water on silica gel	20 ml of water on silica gel	250 ml glass jar
Vegetation	Free-Water Tritium	50 grams	100 grams	double plastic Ziploc bags
Vegetation	Organically Bound Tritium	5 grams	20 grams	double plastic Ziploc bags

[a]Air moisture samples will be collected on a column of indicator silica gel and the total air volume sampled will be measured using a flow controller/totalizer. With the air sampling system that DOE utilizes, the normal amount of air that is sampled per column is approximately 4 m^3. The amount of moisture in air is nominally 10 ml per m^3. Ambient air silica gel samples are routinely blended and split before analysis; one half is submitted for analysis and the other half is stored or submitted to a second laboratory for analysis.

Soil, Sediment, and Surface Water Sampling

Soil and sediment sampling will be conducted in accordance with ERP SOP 3.1. Soil sampling locations will be prepared by first removing all surface vegetation, duff, etc. and then digging to a depth of 6 inches. Soil samples will then be collected using a decontaminated soil drive-sampler loaded with a 0.15-meter (6-inch) long brass liner. Samples will be collected at two depth intervals in the upper 0.6 meters (2 feet) of soil at each sampling location (from 0.15 to 0.3 meters [0.5 to 1 feet] and 0.45 to 0.6 meters [1.5 to 2 feet]). Where the drive sampler cannot be used, samples can be collected with a decontaminated trowel or similar device and the sample placed in a glass jar or metal tube.

Sediment samples will be collected from the upper 0.15 meters (6 inches) using the same methods as described for soil. Surface water samples will be collected in accordance with ERP SOP 2.2. Surface water samples will be collected in 60-ml glass bottles.

<u>Ambient Air Sampling</u>

Air samples will be collected in glass columns packed with a known mass of color indicating silica gel. Columns will be packed shortly before being placed in service to ensure that the indicating silica gel does not settle during the sampling period. One model of tritium sampler is currently in the ambient air network; the model MASS-T-Chart recorder air sampler manufactured by Hi-Q Environmental Products. Calibration and sampling procedures for this system are described in the Ambient Air Sampling and Calibration Procedure (Attachment 4). Volumetric flow meters control the amount of air that passes through the silica gel. Air is pumped through the column at a constant rate of 100 cubic centimeters per minute (0.0035 cubic feet per minute). The silica gel captures any tritium, which is bound to atmospheric moisture. The color indicating silica gel shows how the moisture is advancing through the column during the sampling period, thereby providing advanced warning of potential saturation of sampling media before the collection period ends. Silica gel columns are changed monthly, at which time a new column is installed, the system is verified for proper functioning, and its recorders are reset. When the sample is collected, the sampling technician records current volumetric flow rate, cumulative volume, and elapsed time during the sampling period.

The collected sample is then prepared for laboratory analysis. The silica gel is removed from its glass column, weighed, mixed, and then divided into two equal portions; a primary sample and a split sample. All samples are then bottled, labeled, and securely packaged before any are shipped to the laboratory. The primary sample from each monitoring location is always sent for analysis. The split sample may be sent to the same laboratory for a split analysis, may be sent to Lawrence Livermore National Laboratory's more sensitive Chemistry and Material Sciences's Environmental Services (CES) laboratory for independent split analysis, given to EPA for independent split analysis, or retained at Berkeley Lab for a minimum period of six months in the event that further investigation is needed for that site. Specific details of the split analysis program is present in the *Ambient Air Sampling Plan for Tritium*. The empty glass columns are stored in a safe, clean location until the following sample period (two glass columns are designated for each site, and a given column is in the field every other month).

Vegetation Sampling

Vegetation sampling requirements are specified in the Berkeley Lab Vegetation Sampling Procedure, EH&S Procedure 267. In addition, Berkeley Lab has prepared a Supplement to EH&S Procedure 267 for sampling plant-transpired water. The procedures are included in Attachment 4.

3.3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Custody of samples collected during the field investigation must be traceable at all times to legally responsible parties. The chain-of-custody (COC) form is the primary documentation record required for tracking samples. The COC form records possession of the samples from the time of collection, until disposal of the sample. Written tracking of each sample is also initiated during collection by entries in the following, as appropriate: field notebook, Soil Sampling Data Sheet, Sample Collection Form, Surface Water Sampling Data Sheet, Composite Collection Form, Field Data Collection Form, and/or sample label. Copies of forms are included in the SOPs (Attachment 3 and Attachment 4).

3.3.1 Field Sample Handling and Custody Procedures

Sample handling, custody, packaging, and shipping requirements are specified in the following Berkeley Lab SOPs, which are included in Attachment 3 and Attachment 4.

- ERP SOP 4.3: Handling Packaging and Shipping of Samples
- EH&S Procedure 261 Ambient Air Sampling and Calibration Procedure
- EH&S Procedure 267 Vegetation Sampling Procedure.

Sample preservation is normally not required for tritium; however, samples from all media except air will be shipped to the laboratory in coolers with artificial ice (no water) to minimize biological decomposition. At the laboratory, samples from all media except ambient air will be kept cooled (4 degrees C) and in the dark until analysis.

3.3.2 Laboratory Custody Procedures

To facilitate sample preparation and analysis within the specified holding times, the laboratory will track the progress of sample preparation and analysis. The laboratory will designate a sample custodian responsible for maintaining custody of the samples and all associated paperwork documenting that custody. Each sample received by the laboratory is checked carefully for label identification, COC, and any discrepancies and results of the assessment will be recorded. The laboratory will also record any physical damage, incomplete sample labels, incomplete paperwork, discrepancies between sample labels and paperwork, broken or leaking containers, and inappropriate sample containers. The laboratory sample custodian will notify the appropriate Berkeley Lab Program Manager or his designee of any problems observed with any of the samples received that could affect the quality of the data.

The analytical laboratory will log the samples into its tracking system and assign a laboratory work number for identification purposes. The sample custodian will also log this information onto the COC. Sample custody will be maintained within the laboratory by a secure perimeter, and no unauthorized personnel are allowed to enter without proper identification (such as a visitor's badge).

The original COC form will accompany the laboratory report and will become a permanent part of the project records. Samples received by the laboratory will be retained until after QA/QC auditing has been performed on the analytical results by both the laboratory and Berkeley Lab. Sample containers and remaining sample material will be disposed of appropriately when all analyses and related quality QA/QC work are completed.

3.4 ANALYTICAL METHODS REQUIREMENTS

Analytical information that will be generated under this QAPP consists of concentrations of tritiated water (HTO) in soil, sediment, surface water, ambient air, and plant transpired water; concentrations of tritiated water (tissue free-water tritium [TFWT]) in vegetation, and concentrations of organically bound tritium (OBT) in vegetation. In addition, a limited number of soil (10) and sediment (6) samples will be analyzed for both total tritium and HTO. These samples will generally be collected from locations where the highest tritium concentrations are anticipated in the soil (around the hillside stack) and in the surface water (Chicken Creek). If total tritium activity exceeds 10% of benchmark levels, then as described in the Soil, Sediment, and Surface Water Sampling Plan for Tritium (Attachment 1), additional samples will be collected for analysis of both HTO and total tritium.

Samples will be analyzed by the primary laboratory (Eberline Services) according to the methods noted in the Table 3.2. Split soil, sediment, and surface water samples will be analyzed for HTO by RAML, and by an EPA selected laboratory. Split samples will be analyzed for total tritium or OBT by a laboratory to be determined and/or an EPA selected laboratory.

The water is extracted from soil, sediment, vegetation, and air using an azeotropic distillation method. Azeotropic distillation was selected since it offers the lowest commercially available detection limits and there is no EPA approved method available. EPA Method 906 was selected for the analysis of the extracted HTO since it is the only EPA approved method available. Total tritium and OBT concentrations will be determined using a flame combustion method. Flame combustion was selected since it is the most effective commercially available method. Activities will be counted by liquid scintillation. Copies of the relevant Eberline analytical procedures (CP-210, CP-216, CP-217, and RP-251) and RAML procedures for Method 906 are included in Attachment 5 and 6, respectively.

Table 3.2. Analytical Methods

Media		Method
Water	HTO	CP-210 (simple distillation)
	HTO (duplicates)	906
Soil	HTO	CP-216 (azeotropic distillation)
	HTO (duplicates)	906 (azeotropic distillation)
	Total tritium	RP-251 (flame combustion)
Sediment	HTO	CP-216 (azeotropic distillation)
	HTO (duplicates)	906 (azeotropic distillation)
	Total tritium	RP-251 (flame combustion)
Air	HTO	CP-217 (azeotropic distillation)
Vegetation	TFWT	CP-216 (azeotropic distillation)
	OBT	RP-251 (flame combustion)

Required Reporting Limits (RLs) and units for reporting results for the various media sampled are listed in Table 3.3:

Table 3.3. Reporting Units and Reporting Limits

Media	Reporting Units	Reporting Limits
Water	pCi/L	200 pCi/L (7.4 Bq/L)
Soil	pCi/g	0.2 pCi/g (7.4×10^{-3} Bq/g) HTO;
		5 pCi/g (0.185 Bq/g) total
Sediment	pCi/g	0.2 pCi/g (7.4×10^{-3} Bq/g) HTO
		5 pCi/g (0.185 Bq/g) total
Air	pCi/sample	10 pCi/sample
Vegetation	pCi/g	0.5 pCi/g (1.85×10^{-2} Bq/g) TFWT;
		5 pCi/g (0.185 Bq/g) OBT

Note: total equals OBT and HTO

The actual minimum detectable activity (MDA) is a function of the sample counting time, counter detection efficiency, and background levels. The 200 pCi/L (7.4 Bq/L) reporting limit for water for this project is two orders of magnitude lower than the drinking water standard. The 0.2 pCi/g (7.4×10^{-3} Bq/g) reporting limit for soil and sediment samples is approximately five orders of magnitude lower than the PRG for residential soil. The 10 pCi/sample-reporting limit for air samples is several orders of magnitude below the regulatory limit. The 0.5 pCi/g ($1.85x10^{-2}$ Bq/g) reporting limit for vegetation samples for TFWT and 5 pCi/g [0.185 Bq/g] for OBT represent the lowest commercially available detection limits. There are no explicit regulatory standards for tritium in vegetation or plant-transpired water.

3.5 QUALITY CONTROL REQUIREMENTS

QC requirements for laboratory and field activities are discussed in the following subsections.

3.5.1 Laboratory QC Requirements

Laboratory QC samples include method blanks, laboratory control samples (LCS), matrix spike/matrix spike duplicates (MS/MSD), and laboratory duplicate samples. Required laboratory quality control samples, acceptance criteria, and corrective action if control limits for these control samples are exceeded are listed in the Table 3.4. Eberline Services' quality assurance procedures are included in Attachment 7.

Table 3.4. Summary of Laboratory Quality Control Procedures

QC Check	Frequency	Acceptance Criteria	Corrective Action if Out of Acceptance Criteria
Method Blank	1 per preparation batch or maximum of 20 samples	≤RL	1) Investigate and correct source of contamination 2) Reanalyze associated samples
LCS	1 per preparation batch or maximum of 20 samples	%R=80% to 120%	1) Determine and correct source of error 2) Reanalyze associated samples
MS/MSD (water only)	1 per preparation batch or maximum of 20 samples	%R=75% to 125% RPD<35%	1) Investigate source of error 2) Reanalyze samples. If results are similar, flag MS recoveries as attributable to matrix effects and report both sets of data.
Laboratory Duplicate	1 per preparation batch or maximum of 20 samples	RPD<50%	1) Investigate source of error 2) Reanalyze samples. If results are similar, flag recoveries as attributable to matrix effects and report both sets of data.

Method Blanks

Method blanks will be run to verify that sample analysis does not introduce contaminants that affect the analytical results. One method blank will be included for each sample group and analyzed with field samples prepared under identical conditions. The method blank consists of distilled water for soil, sediment, water and vegetation samples. For ambient air samples, the method blank consists of 100 grams (3.5 ounces) of silica gel exposed to the atmosphere overnight.

Analytical results for each sample shall be clearly associated with a particular method blank. Any detected concentration of tritium found in method blanks is reported. If tritium is detected in the blank, an investigation is conducted to identify the source of contamination and corrective action taken, including reanalysis of the sample group, if appropriate.

Laboratory Control Samples

Laboratory control samples (LCSs) consist of interference-free water spiked with known concentrations of tritium. LCSs are used to document laboratory performance by checking the precision and accuracy of the analytical procedure, free of matrix effect.

The percent recovery of the LCS is calculated and compared with the limits listed in Table 3-4. If results are outside these limits, the analysis is considered to be outside acceptance limits and corrective action is taken. Corrective action will include identifying and correcting the reason for the unacceptable performance, and reanalyzing the sample group. Every analytical batch will include an LCS.

LCS percent recovery (%R) is calculated as follows:

$$\%R = \frac{SR}{SSR} \text{ x } 100\%$$

where:

SSR = analyte concentration of spiked sample

SR = sample result

Matrix Spike Matrix Spike Duplicate

A matrix spike/matrix spike duplicate (MS/MSD) pair consists of two separate aliquots of a field sample spiked with equal known concentrations of tritium. The MS/MSD samples are then analyzed using the same protocols as are used for the unspiked sample aliquot to assess the bias and precision of the method.

Spike levels will vary so that recovery versus concentration information can be obtained. Samples will be spiked at three different concentrations in the range of 10 to 30 times the MDA (e.g. at 10, 20, and 30 times the MDA).

The matrix spike percent recovery (%R) and the RPD between the concentration of the matrix spike and matrix spike duplicate are calculated and compared with the limits listed in Table 3-4. If results are outside these limits, the analysis is considered to be outside acceptance limits and corrective action is taken.

Matrix spike percent recovery (%R) is calculated as follows:

$$\%R = \frac{SSR - SR}{SA} \text{ x } 100\%$$

where:

SSR = analyte concentration of spiked sample

SR = analyte concentration of unspikcd sample

SA = actual concentration of analyte added to the sample.

RPD is calculated as follows:

$$RPD = \frac{(|X_1 - X_2|)}{0.5(X_1 + X_2)} \text{ x } 100\%$$

where:

X_1 = Concentration of matrix spike sample

X_2 = Concentration of matrix spike duplicate sample.

Laboratory Duplicate Samples

A laboratory duplicate sample consists of two separate aliquots of a field sample. The duplicate sample results are used to assess the precision of the analytical method. The RPD between the concentration of the primary sample and the laboratory duplicate is calculated and compared to the limits established for this project (See table 3-4). If results are outside these limits, corrective action is taken. Variability in laboratory duplicate sample results, however, may be an indicator of matrix variability and inhomogeneity rather than an indication of poor laboratory performance.

3.5.2 Field QC Requirements

Field QC requirements will generally include the collection of duplicate and split samples. In addition, trip blanks will be collected for ambient air and transpired water samples; equipment rinse blanks will be collected for soil and sediment samples; and field blanks will be collected for surface water samples.

Field Blanks, Equipment Rinse Blanks, and Trip Blanks

Blanks give an indication of possible contamination in the sample collection or analysis process. If tritium is detected in a blank, the source of the contamination will be investigated and the corresponding primary samples will be flagged in the database. The sample media and required frequency for the collection of blank samples are indicated in Table 3.5.

Table 3.5. Summary of Blank Sample Requirements

	Ambient Air	Soil	Sediment	Surface Water	Transpired Water	Vegetation
Equipment Rinse Blank	Not required	1 per day	1 per day	Not required	Not required	Not required
Field Blank	Not required	Not required	Not required	1 per day	Not required	Not required
Trip Blank	1 per shipment	Not required	Not required	Not required	One per cooler	Not required

Equipment Rinse Blanks

Equipment rinse blanks are used to evaluate field sampling and decontamination procedures. The equipment rinsate blank will be collected by pouring deionized water over the decontaminated sampling equipment. The blanks will be collected after the maximum anticipated concentration sample of each day. The sample identification numbers assigned by Berkeley Lab to the equipment rinse blanks, as well as all packaging and shipping efforts, will make these samples indistinguishable from the actual samples.

Field Blanks

Field blanks are used to evaluate whether contaminants have been introduced into the samples during sampling procedures. Field blanks will be collected for surface water samples. Surface water field blanks will be collected by pouring deionized water into a sampling container at the sampling location. The sample identification numbers assigned by Berkeley Lab to the field blanks, as well as all packaging and shipping efforts, will make these samples indistinguishable from the actual samples.

Trip Blanks

Trip blanks will be collected to monitor contamination that may be introduced during transportation of samples. For all media except air, the trip blank will consist of a sample vial filled with deionized water. Each trip blank will be supplied by the laboratory and will accompany the laboratory-supplied sample vials. For ambient air, a trip blank will consist of a regular sized sample column filled with color indicating silica gel. Berkeley Lab will supply materials for the ambient air trip blank.

Field Duplicates/Splits

A field duplicate consists of two samples collected independently at a sampling location during a single sampling event (collocated samples). Duplicate results can be used to check interlaboratory comparability (for samples sent to different laboratories) and variability of results at a given location. A split sample consists of two or more representative portions taken from a sample or subsample and sent to different laboratories to measure primary laboratory accuracy in analysis. The acceptance criteria for duplicate/split samples is 50% RPD or a relative error ratio (RER) of less than 1.0. As noted previously, variability in duplicate sample results may only be an indicator of matrix variability and inhomogeneity. If the RPD acceptance criterion is exceeded, sample results and QC results will be reviewed and compared to determine the source of the variation.

Relative Error Ratio is calculated as follows:

$$RER = \frac{R - S}{STDr + STDs}$$

where:

S = Sample result

R = duplicate (replicate) result

STDr = Two sigma standard deviation of the duplicate result at the 95% confidence level.

STDs = Two sigma standard deviation of the sample result at the 95% confidence level.

A summary of duplicate and spilt sample requirements is presented in Table 3.6.

Table 3.6. Summary of Minimum Field Split and Duplicate Sampling Requirements

Media	Tritium Analysis Type	Total Primary Samples (includes background)	Split Samples[a]			Duplicate Samples		
			Minimum Number	Minimum Percentage	Laboratory	Minimum Number	Minimum Percentage	Laboratory
Soil	HTO	132	20	10%	RAML	24	20%	Eberline
	Total	10	2	20%	[b]	2	20%	Eberline
Sediment	HTO	36	4	10%	RAML	6	20%	Eberline
	Total	6	2	30%	[b]	2	30%	Eberline
Surface Water	HTO	72	8	10%	RAML	10	20%	Eberline
Air	HTO	180	24	10%	Eberline & CES[c]			
Tree wood	TFWT and OBT	18	2	10%	[b]	2	10%	Eberline
Leaves		18	2	10%	[b]	2	10%	Eberline
Duff		18	2	10%	[b]	2	10%	Eberline
Transpired Water	HTO	4	2	50%	RAML	2	10%	Eberline

Notes:

(a) An equal minimum percentage of split samples will be made available to EPA for shipment to a laboratory specified by the EPA QA office.
(b) Laboratory to be determined.
(c) Each laboratory will receive these minimum number of samples.

Vegetation and transpired water samples will be collected during two independent sampling events. Surface water and sediment samples will be collected from flowing creeks during two independent sampling events. In addition, surface water samples will be collected monthly from Chicken Creek and North Fork Strawberry Creek from October to March.

Soil, Sediment, and Surface Water

Duplicate soil and sediment, samples will be collected immediately adjacent to the primary sample location, at the same depth as the primary sample. Soil, sediment, and surface water samples will be split three ways and analyzed by Eberline Services, RAML (HTO) or another laboratory (OBT or total tritium), and EPA's designated laboratory.

Ambient Air

Two equal portions of the collected sample are created for each ambient air monitoring location by thoroughly mixing the silica gel in a controlled environment prior to shipping the sample for laboratory analysis. At least 10 percent of the locations (two monitoring locations each month under the expanded network) will have the split sample analyzed by Eberline Services. The AASP rotates the location from where the split is analyzed each month. The remaining split samples will be made available to the EPA for analysis at a laboratory that they select.

Vegetation

Duplicate leaf, duff, wood, and transpired water samples will be collected at sampling location Number NNW1 shown on Figure 2.5. The duplicate samples will be collected as close as practicable to the primary sample locations. Transpired water samples will be split three ways and analyzed by Eberline Services, RAML, and EPA's designated laboratory. Split wood, duff, and leaf samples will be analyzed by Eberline Services and the EPA designated laboratory,

3.6 INSTRUMENT / EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

Requirements for inspecting, maintaining, and calibrating ambient air sampling equipment are contained in EH&S Procedure 261, which is included in Attachment 4. Eberline Services instrument testing, inspection, and maintenance requirements are discussed in their Quality Assurance Program Manual. The relevant sections of the manual are included in Attachment 7 as indicated in Table 3.7.

Table 3.7. Eberline Services Instrument/Equipment Requirements

Item	Section of Eberline Services Quality Assurance Program Manual
Preventative Maintenance	10
Reports Generated From Use of a Deficient Instrumen	11
Performance Checks of Radiation Screening Instrume	11
Certification and Certificates of Calibration	11
Instrument Calibration Status	11

3.7 INSTRUMENT CALIBRATION AND FREQUENCY

Laboratory

All analytical instruments will be calibrated according to the QA criteria of the designated laboratory. Eberline Services calibration requirements are included in Attachment 7. Instrument counting performance is determined weekly by the Eberline Services QA manager. The laboratory's calibration program verifies that equipment is of the proper type, range, accuracy, and precision to provide data compatible with specified requirements. All equipment whose operation and function directly affect the quality of data is calibrated at established intervals. Records of calibration results are maintained in the instrument logbook.

Calibration may either be performed by laboratory personnel using reference standards or by calibration agencies or equipment manufacturers. Recognized procedures shall be adopted such as America National Standards Institute ANSI N42.15-1997, *Performance Verification of Liquid Scintillation Counting Systems* and Draft ANSI Standard N13.30 *Performance Criteria for Radiobioassay*. Instrument performance assessment of the liquid scintillation counter is done by the internal software of the manufacturer using National Institute of Standards and Technology (NIST) standards.

The laboratory will establish control limits for background and efficiency according to the quality assurance procedures included as Attachment 7. In the event a QC value fails, no sample can be analyzed until the problem has been corrected and the QC data fall within acceptance criteria.

Field

No field calibration is required for soil, sediment, surface water, or vegetation sampling equipment. Calibration requirements for air sampling equipment are discussed in the Ambient Air Sampling and Calibration Procedure (see Attachment 4). Calibration standards for ambient air sampling equipment shall be NIST-traceable, and certificates shall be provided by the manufacturer.

3.8 INSPECTION / ACCEPTANCE CRITERIA FOR SUPPLIES AND CONSUMABLES

Laboratory

Inspection / acceptance criteria for laboratory supplies and consumables are included in Attachment 7.

Field

Sampling equipment (brass tubes, wood augers, glass columns, silica gel etc.) will be inspected to assure they are clean. Disposable latex gloves, plastic bags, and other sample containers will be inspected for cleanliness and integrity. Glassware connectors for ambient air sampling will be inspected for wear each time the columns are refilled.

3.9 DATA ACQUISITION REQUIREMENTS (NON-DIRECT MEASUREMENTS)

Nondirect measurements will not be generated during this sampling program.

3.10 DATA MANAGEMENT

The analytical laboratory will be responsible for preparing a report summarizing the results of analysis and for preparing a detailed data package. The ERP or the ESG data manager (depending on the sample type) will review the laboratory analytical reports to assess the completeness of the data. Completeness will be assessed by comparing the analytical reports to the analytical requirements specified on the COC forms. After initial review, the ESG data manager will import the electronic files for air and vegetation sampling into the ESG environmental monitoring management system database, where the data will be stored and managed as described in the Environmental Tracking and Data Management Procedure (Attachment 3 and 4). The ERP data manager will enter soil, sediment, and surface water data into the ERP database, where it will be stored and managed according to requirements of the ERP Data Management Plan (Berkeley Lab 1992).

Reports, laboratory data, and other records will be stored at Berkeley Lab for a minimum of three years after completion of the project and then transferred to the Berkeley Lab Archives and Records Office for storage in accordance with CERCLA requirements.

SECTION 4

ASSESSMENT / OVERSIGHT

4.1 ASSESSMENT AND RESPONSE ACTIONS

4.1.1 Technical System Audit

The QAM will complete one Technical System Audit (TSA). A TSA is a thorough and systematic qualitative onsite audit where equipment, personnel, training, procedures, and record keeping are examined for conformance with requirements of the QAPP. The TSA will encompass field sampling activities, data validation, and data management. All findings will be documented in writing to the ESG leader and communicated to the appropriate Program Manager when the assessment is complete. A copy of the TSA report will be provided to EPA for review, together with a discussion of all proposed corrective actions and corrective actions taken as a result of the audit.

The TSA will include a field audit to check on sample collection and sample handling procedures. The field audit will include:

- A review of compliance with requirements of the QAPP and Sampling Plans
- On-site visits, which will include observation of field personnel as they perform all aspects of the sampling programs: field equipment calibration, equipment decontamination, sample collection, sample packaging, and documentation. The on-site visits will also include a review of data collection forms, COC forms, calibration procedures, etc. The auditor will also talk individually with field personnel to determine consistency of sampling procedures and adherence to the approved sampling plan.

4.1.2 Laboratory Performance Evaluations

<u>Performance Evaluation Programs</u>

The analytical laboratories must have in place a formal program of system and performance audits, including participation in both internal and external performance evaluation programs. Laboratory QA Managers must notify the ESG Leader in writing if the results of systems or performance audits indicate impacts to data quality objectives.

Eberline Services participates in the DOE Environmental Monitoring Laboratory intercomparison program for tritium analyses. The following Eberline Services performance evaluation reports are included in Attachment 8:

- DOE Mixed Analyte Performance Evaluation Program
- EPA Performance Evaluation Studies (1996 to 1998)
- DOE Laboratory Accreditation Program (DOELAP) Pilot Tests
- Semi-Annual Reports of the DOE Office of Environmental Management Quality Assessment Program (July 1997, January 1998, and July 1998).

The audit report on Eberline Services to document performance and capabilities as a qualified subcontractor for analytical work at Berkeley Lab and Lawrence Livermore National Laboratory is included in Attachment 9.

Project Performance Evaluation Samples

EPA, at their discretion, may provide performance evaluation (PE) samples to Berkeley Lab for submittal to the analytical laboratories or submit PE samples directly to the laboratories. In addition, as requested by EPA, Berkeley Lab will submit double blind soil, sediment, and water samples (2 minimum for each media) to the analytical laboratories. Equivalent (equal concentration) or split double blind samples will be obtained from EPA and will be submitted to Eberline Services, RAML, and the EPA designated laboratory. Results of double blind soil samples are questionable, however, since the distribution of tritium in the samples will not be uniform and the whole sample is not generally included for analysis.

4.2 REPORTS TO MANAGEMENT

No written reports to management are anticipated for the activities covered by this QAPP.

SECTION 5

DATA VALIDATION AND USABILITY

5.1 DATA REVIEW, VALIDATION AND VERIFICATION REQUIREMENTS

A separate Data Verification and Validation Plan has been prepared for this project (Berkeley Lab 2000). The general data validation and verification process is described in the following paragraphs.

After field sampling activities are completed, the appropriate Program Manager (or his designee) reviews all field reports and COC forms to assess compliance with requirements specified in this plan, as follows:

- Required sampling procedures were followed
- Samples were collected at the appropriate locations and frequency.
- Soil and sediment samples were collected at the specified depth
- All required information has been entered onto the COC and field collection forms
- The required number of QC samples was collected.

The appropriate Program Manager (or his designee) will review the records of field data collection and laboratory reports to determine if the laboratory reporting is accurate and complete and to assess compliance with QC requirements specified in this plan and the operating contract with Berkeley Lab. If the reports are incomplete or in error, the appropriate Program Manager will request that the laboratory submit revised reports. The Program Manager (or his designee) will then review the reports to evaluate whether:

- The required analyses were conducted
- Analyses were conducted within required holding times
- No analytes (tritium) were found in blanks

- Results of LCS, MS/MSD, blanks, split samples, and duplicate samples were within acceptance limits
- Samples were analyzed at the required RL.

Analytical results will be deemed valid if the following conditions are met:

- Sample integrity has not been compromised by missed holding times or inappropriate storage or handling, and
- Laboratory calibration criteria have been met and laboratory QC samples have met the acceptance criteria established in this plan.

A minimum of 10% of the data will be fully validated by a source independent of data generation.

Individual analytical results will be validated against the acceptance criteria. Valid data will be entered into the appropriate database. Data tables in the final report will be checked against the original laboratory reports.

The appropriate Program Manager may request that the laboratory review and reevaluate results and reporting procedures if outliers are reported that may have been the result of laboratory analytical or transcription error. If the cause is the result of laboratory error, the laboratory may be requested to reanalyze the sample and submit a revised analytical report.

5.2 RECONCILIATION WITH DATA QUALITY OBJECTIVES

Data that are determined to be invalid will be identified by data qualifier "flags" in the database and in the tables in the final report. If results of duplicate or split samples are above the acceptance criteria specified in this plan, the results will be reviewed and evaluated. Duplicate and split sample results above the acceptance criteria established in this plan may not indicate invalid data, but may be the effect of matrix variability and inhomogeneity. If the variability can be attributed to matrix variability or inhomogeneity, results will be considered valid.

The appropriate Program Manager or his designee will review the results of the investigation to ensure compliance with the DQOs specified in this plan.

SECTION 6

REFERENCES

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